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SOUTH AUSTRALIA.

SOUTH AUSTRALIAN RAILWAYS.

REPORT

ON

OBSERVATIONS ON RAILWAYS,

AND

OTHER SUBJECTS,

MADE

DURING A TOUR IN 1883,

UNDER

The Direction of the Government of South Australia.

By HENRY C. MAIS, M. Inst. C.E., Lond.;
M. Soc. Engrs., Lond.; M. Amer. Soc. C.E.;
ENGINEER-IN-CHIEF OF SOUTH AUSTRALIA.

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[*Letter*

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[*Letter of Instructions addressed to Engineer-in-Chief by the Honorable Commissioner of Public Works.*]

South Australia,
Office of Commissioner of Public Works,
Adelaide, November 22nd, 1882.

Dear Sir—I have jotted down a few things to which I wish you to give your special attention as opportunity offers during your projected tour through Europe and

ERRATA.

Page.	
9.	Tenth line from bottom, instead of "to break" read "with their."
11.	Eighteenth line from bottom, instead of "1,200" read "12,000."
14.	Twenty-fourth line from bottom, instead of "running" read "receiving."
35.	Seventh line from top, instead of "in use" read "existing."
36.	Fifth line from top, for "vaccum" read "vacuum."
39.	Eleventh line from top, instead of "County" read "Country."
45.	Sixteenth line from top, insert comma after word "Coast."
61.	Thirty-eighth line from top, instead of "Scotland" read "Wales."
76.	Last line, instead of "relegate" read "delegate."
78.	Eighth line from top, for "12£" read "£21."
80.	Thirty-first line from top, instead of "was" read "were."
82.	Twentieth line from top, instead of "ballast-rails" read "ballast, rails."
83.	Twenty-fourth line from top, instead of "enable" read "enables."
88.	Last line, instead of "ariel" read "aerial."
91.	Thirty-second line from top, instead of "rachet" read "ratchet."
91.	Forty-seventh line from top, instead of "then ames" read "the names."
99.	The two paragraphs referring to Cape Railways should have been placed between Indian and English Railways.
99.	Eighteenth line from bottom, for "35" read "25."
101.	Fifth line from top, for "35" read "25."
101.	Eighth line from top, for "Monkridge" read "Monkbridge."
102.	Eighteenth line from top, for "constitute" read "constitutes."
103.	Sixth line from top, for "Speigel" read "Spiegel."

16. Railway station luggage lifts, traversers, &c.

17. Railway bridges generally—Swing and pontoon.

18. Railway bridges—American, as applied to River Murray.

19. Railway station cranes, hydraulic turntables, &c.

20. Piers, wharves, breakwaters, cranes for ditto, and appliances.

21. Gas compressed for lighting buoys and carriages.

22. Dredging by special machinery for hard ground.

23. Dock construction in timber and stone.

24. Chance Bros. *re* Corny Point Lighthouse.

25. Inquire into working of engineer's branch of Agent-General's department.

26. Ascertain

26. Ascertain manufacturers of best and second best brands of wrought-iron plate for girder work, and for galvanized iron; also relative market values.

27. Arrangements for maintaining railway lines, average number of men to the mile, single lines.

28. Best kind of dynamometer for measuring draft of trains, especially round curves.

29. The cheapest and best system of filtering water to supply cities or towns.

30. The best known closet-trap that has been in use.

31. Wire-rope or other railways for hilly country suitable for bringing goods from mines, quarries, &c., to main line.

32. Mode of extinguishing fires.

33. Well-boring apparatus.

34. Windmills for pumps, &c.

35. And any other subjects that may be of interest and useful in the colony as regards railways or public works with which you are connected.

J. G. RAMSAY,

Commissioner of Railways and Waterworks.

H. C. Mais, Esq., M.I.C.E., Engineer-in-Chief.

SOUTH AUSTRALIA.

REPORT OF ENGINEER-IN-CHIEF.

Engineer-in-Chief's Office, Adelaide, December 24th, 1883.

The Hon. Commissioner of Public Works—

Sir—Prior to leaving South Australia on the 25th of November, 1882, for the purpose of visiting England and the United States, I received a list of subjects to which the Minister of Railways desired that I should, during my absence from the colony, give special attention as opportunity offered. I have now the honor to report as follows, under the respective headings:—

Item No. 1.—THE MOST ECONOMICAL SYSTEM OF CONSTRUCTING AND WORKING RAILWAYS, TAKING INTO CONSIDERATION PROBABLE TRAFFIC, SPEED, &c.

This is a subject which would occupy much longer time to thoroughly investigate than I had at my disposal for the whole trip (viz., six months), and I therefore cannot state which is the most economical system of constructing and working railways beyond the fact that I find the lines that have been well constructed are much more economically worked than cheaply made lines of railway.

CEYLON RAILWAYS.

Ceylon Railways.

The first railway upon which I travelled after leaving South Australia was that which has been working for the past twelve years between Colombo and Kandy, in Ceylon. This line is seventy-five and three-quarter miles in length, and passes through easy country as far as Rambukkana, fifty-two and a half miles from Colombo, the gradients on this portion not being steeper than 1 in 100, and the curves not less than 20 chains radius; but from this point the most interesting portion of the line commences, with a rising gradient of 1 in 45 for twelve miles, rising in that distance 1,408ft. to the summit level of 1,618ft. above the sea. The line is well and carefully laid out round the slopes and precipitous sides of the mountain ranges, necessitating ten tunnels through rock, as well as heavy cutting, and curves of 10 chains radius. The permanent way was originally laid with iron rails 70lbs. to the yard; but they speedily became worn with the traffic, and were replaced with steel rails 72lbs. to the yard. From the head of this incline of 1 in 45 into the town of Kandy, the line follows a valley, which necessitates the frequent use of curves of 10 chains radius. This railway was opened for traffic in 1861, and cost £873,039, or £11,718 per mile of single line, 5ft. 6in. gauge. The sleepers were originally of Baltic timber creosoted, spaced 2ft. 7½in. apart, or eight sleepers to each 21ft. rail. The two intermediate and the joint sleepers were native wood, to which the rails were fanged, and were spiked to the remainder in the ordinary manner.

Locomotives.

The engines used for working the line between Colombo and Kandy are goods engines of the ordinary type, with inside cylinders 16in. diameter and 22in. stroke, with driving-wheels 5ft. diameter, four wheels being coupled, and having a rigid wheel-base of 8ft. The front of the engine is carried on a four-wheel bogie truck, fitted with lateral and swivelling motions, the wheels being 3ft. in diameter, and the total weight of the engine alone in steam 35 tons. The tender has six wheels 3ft. 6in. diameter, carrying a flat-top tank holding 1,500 gallons of water.

The 1 in 45 incline is worked with the aid of a Bank engine, which has outside cylinders 17in. diameter and 26in. stroke, with six coupled wheels 4ft. 5in. diameter and a rigid wheel-base of 9ft. 6in., the weight available for adhesion being 32½ tons. The tender has six wheels each 3ft. 6in. diameter, and carries a flat-top tank containing 1,500 gallons of water. The fuel used is wood, ten cubic yards costing 30s. in English money, and being equal to one ton of coals costing 46s. per ton. When in full work the consumption of fuel is 1cwt. of coals per mile and the evaporation of water in ascending the twelve miles of the incline is 1,400 gallons. The carriages are of the ordinary type, having a wheel-base of 9ft. 6in., and the wagons a wheel-base of 8ft.

Working 1 in 45 incline.

The following method is adopted for working the 1 in 45 gradient:—"All ascending passenger trains "have an assisting engine in the rear, and when the load does not exceed sixteen vehicles, the train engine is "placed in front and the Bank or assisting engine of the goods class is placed in the rear. When the load "exceeds this number the Bank engine is placed in front and the train engine in the rear.

"In descending the incline no additional brakevans are used, but every passenger vehicle (except the "first-class carriages) is fitted with an independent self-acting brake worked by a spring, and tightened up "by the guards before descending, and requiring no attention until they arrive at the foot of the incline. "Trains consisting of fifteen to thirty carriages have frequently descended this incline with perfect safety "and regularity. "The

Goods trains.

"The goods trains are composed of twenty-four loaded trucks (each weighing 11 tons) and one brakevan "from Colombo to the foot of the incline, where (6) six of the wagons are shunted off, and the train is made "up of seventeen loaded trucks and two brakevans. The goods engine (whose duty is to haul twelve loaded "trucks and a van) is then placed in front of the train, and the train engine placed in the rear propels the

Indicator.

"remaining five wagons and brakevan. The vehicles are fitted with an indicator, by which the rear engineman "is informed when his engine is doing more than her allotted share of work.

"In descending the incline one heavy brakevan, in addition to the ordinary trainvan, is placed in the centre "of the train, and a weight of 50lbs. is hung on the end of all the brake-levers of the trucks. These "weights retard the speed of the trains sufficiently, the brakevan and tender-brakes being used as reserves, "and for stopping the trains. The limit of load for goods trains descending this incline is twenty-four loaded "wagons and two brakevans. Two, and sometimes three, locomotives are attached to the front of the train; "and it has not been found that this practice produces the jars and shocks which were anticipated. The "number of daily trains traversing the incline varies from twelve to fourteen, exclusive of "specials," and, "although it has been worked for more than twelve years, no accident has yet occurred whereby any passenger "has been injured.

Speed.

"The traffic is worked on the 'staff' and block (electric) systems, from three telegraph stations about "four miles apart. The staff system is also used throughout all the railways in Ceylon. The speed fixed for "goods and passenger trains is twelve miles per hour on the incline."

EGYPTIAN RAILWAYS.

Egyptian Railways.

The railway between Suez and Alexandria was, at the time of my visit, in a very bad state of repair, especially near Alexandria, owing to the late war, and the carriages were neither clean nor comfortable.

Nothing upon this line calls for any further remark.

ITALIAN RAILWAYS.

Italian Railways.

With regard to the Italian railways I found that there were originally three private railway companies —The Alta Italia, the Roman Railway Company, and the South Italian Railway Company.

The Italian Government provided, and continues to provide, for the construction of the Calabro Sicilian railways, and have made an agreement with the South Italian Railway Company for working them. At the present time (1883) the Alta Italia and Roman Railway Companies have been redeemed by the Government, and the Southern Italian Railway Company only remains as a private company, also working the Calabro Sicilian lines.

The fact that the Government has obtained possession of the Alta Italia and Roman lines does not alter the regulations under which the lines are worked, excepting that the general control is derived from the Corte de'l Conto.

The organisation of the Alta Italian line is as follows:—

Alta Italia.

There is a board of directors nominated by the Government which possesses the same powers as formerly belonged to that of the private company.

There is also a general director of traffic residing at Milan, having under his control the following departments:—

1. The maintenance of the lines and the stores belonging thereto.
2. The secretary's department.
3. The accountant's department.
4. Telegraph department and stores.
5. Rolling-stock, and repairing shops and stores.
6. Traction department and stores, including coals.
7. Traffic department.
8. Legal department.
9. Receipts department (comptroller of revenue).

The organisation of the Roman lines is as follows:—

Roman.

There is a board of directors nominated by the Government, with the same powers as those formerly belonging to the private companies; also, one general director of traffic residing in Florence, having under his control the following departments:—

1. Maintenance of the lines.
2. Rolling-stock, repairing shops, and traction departments.
3. Stores department.
4. Traffic department.
5. Accountant's department.
6. Comptroller of receipts department.
7. Legal department.
8. Telegraph department.
9. Secretary's department.

Southern

Southern Italian Railway Company (Private).

This is controlled by a board of directors nominated at a meeting of the shareholders, having a director-general—residing in Florence—who has under his control the following departments:— Southern

1. The general secretary's department.
2. The legal department.
3. The audit department.
4. The accountant's department.
5. The supply department.

The traffic is managed by a general manager, residing in Ancona, who controls—

1. The traffic working.
2. The rolling-stock, repairing shop, and traction department.
3. The receipts department.
4. The telegraph department.

The construction is under the direction of one engineer, residing in Naples, who has the two departments, viz.:—

1. The construction department.
2. The maintenance department.

The general manager, residing in Ancona, is controlled by the director general, who resides in Florence.

In thinly-populated districts, the only difference made in the service of the railway is that the traffic is conducted by mixed trains and goods trains, *i.e.*, goods and passenger trains together in a small number per diem.

ST. GOTHARD RAILWAY.

As I travelled over the St. Gothard railway into Switzerland, a short description of this wonderful engineering work may be interesting. (Plate 1, appendix.) St. Gothard Railway. Plate 1.

Leaving Milan the line runs to Como, thence *via* Lugano and Traverne to Bironico. The line enters the Como. Monte Cenere tunnel (one mile in length) just beyond this point, which is 1,440ft. above sea-level, and descends with a grade of 1 in 90 to Gubiasco, passing in its course steep and rocky gorges spanned by iron lattice girder bridges on masonry piers, to Bellinzona and Giornico, where there is a fine specimen of an iron Giornico. lattice bridge in two spans of 150ft. each. Just beyond Giornico the first helical or spiral tunnel (de Travi) Spiral tunnels. commences, the approaches to which have necessitated very heavy work through granite formation. The tunnel is 1,690 yards long, and adjacent to it is the second spiral tunnel of Piano Toredo, 1,650 yards in length.

The adoption of spiral tunnels was rendered necessary in order to obtain a considerable elevation where the nature of the ravine would not allow of any rapid changes in the levels, and consequently the line was taken into the side of the mountain, and by means of sharp curves of 15 chains radius and a steep grade of 1 in 44, it emerged again at a much higher level than that at which it had previously entered—but the fact of having two spiral tunnels so close together as those at Travi and Piano Toredo is unique. Beyond Faido, about one and a half miles, is the third spiral tunnel, de Prato, which is 1,700 yards in length; and passing onwards about two and a half miles the fourth spiral tunnel, de Freggio, which is about 1,720 yards long, is entered; the line then passes through comparatively easy country to Ambri, and by ascending a grade of 1 in 40 Airolo is reached at a level of 3,756ft. above the sea. Just beyond this point the great tunnel, which is nine miles 468 yards long, commences. It is 19ft. 8in. in height, and has a minimum width of 24ft. 11in. The grade in the tunnel rises about 1 in 500 for nearly half its length, and then descends at 1 in 172 to Göschenen, which is 3,638ft. above the sea-level. The Kastelhorn, which is the name of the Kastelhorn. mountain immediately over the tunnel, rises to a height of 9,387ft. above sea-level. This tunnel is constructed for a double line of rails throughout its entire length. Double line throughout.

From Göschenen the line passes through three tunnels into the fifth spiral tunnel, de Leggistein, and thence to Wasen, after which it passes through the sixth spiral tunnel, de Wattingen. The tunnel de Leggistein is 1,200 yards in length, and the tunnel de Wattingen is about the same; and just below this last tunnel is another, the seventh and last spiral tunnel, de Pfaffensprung. Each of these tunnels has the same grade of 1 in 40. Just before reaching Wasen there is a magnificent view of the railway, which appears as if there Wasen. were three railways one above the other and quite disconnected, whereas the one line traverses the side of the mountain, returning again by means of the two spiral tunnels.

From Wasen the line runs down to Anstey, and thence to Fluelen. On this portion of the line there Fluelen. are some fine examples of lattice girder bridges. From Fluelen, on the margin of the Lake of Lucerne, to Brunnen, the line passes through nine tunnels in seven miles—that at Sisikon, called the Oelberg, being upwards of 2,000 yards in length. After leaving Brunnen the line runs to Goldau, and joins the Rigi railway; from thence it continues along the base of the Rigi to Immensee.

The cost of construction of this railway has been about £7,000,000, and towards this amount the Cost of construction. governments of Switzerland, Germany, and Italy have contributed. The company was organised in 1871 for the construction of this line, and a contract was let in 1872 to Monsieur Louis Favre, the famous engineer and contractor of Geneva, for the construction of the tunnel through the Alps from Airolo to Göschenen for the sum of £2,000,000. the work to be completed within eight years under heavy penalties.

The

Rockdrills. The drilling at the Airolo end was commenced by rockdrills, driven by steam; but subsequently McKean's drills were used, worked by six turbines, 16ft. 6in. in diameter, under a head of water of 540ft., and at the Göschen end of 280ft. The daily working averaged about twenty-six holes, each 4ft. deep, in a face 6ft. square; and the progress was as much as 20ft. per day of heading. The turbines * worked sixteen air compressers, which supplied air sufficient to work twenty rockdrills.

Turbines.

The Pfaffensprung tunnel was worked by boring machines which were the invention of Mr. Brandt, and were worked with water under very high pressure. The drill, being hollow, allowed the rock particles to escape through the centre; and it is stated that these drills will cut the hardest rock with ease and freedom from jar, which is so destructive to the air-compressed drills. There cannot be any doubt that this railway is, without exception, one of the finest specimens of engineering skill in Europe; but at the same time great diversity of opinions exists as to the necessity for such a stupendous work, many urging that by proper mechanical appliances a gradient of 1 in 10 could have been constructed at one-third less cost; but the ruling gradient of 1 in 40 was fixed by the International Conference, and therefore no blame can be attributable to the able engineers who planned and carried out this great work.

Locomotives. The number of locomotive engines used for working the St. Gothard railway is sixty-one, of which fourteen are tender engines used for passenger trains on flat country; thirty are six wheels coupled (4ft. diameter), for passenger trains on inclines, and for goods trains on flat country; fifteen are eight wheels coupled, for goods trains on inclines. Besides these there are two small engines and tenders used for light trains.

Second line. It is proposed to increase the number of train engines from fifty-nine to seventy-six in consequence of its having been decided to lay a second line of rails through the whole length of the tunnel. The following are the principal dimensions of the 8-wheel coupled engines made by Herr Maffei, of Munich:—Outside cylinders, 20·48in. diameter; ditto, 24in. stroke; wheels (8) all coupled, 3ft. 10in. diameter; effective pressure, 102½lbs. per sq. in. of piston area; weight, in working order, 51 tons, all available for adhesion; axles 4ft. 3·1in. apart; equally spaced; total wheel base, 12ft. 9·3in.; boiler containing 225 tubes 1·97in. diameter outside, and 13ft. 9½in. long. The engines were built at the workshops of Eslingen, Winterthur, Maffei, and Kraus, in Munich (Bavaria).

Carriages. The number of carriages and wagons used on this line is—carriages, first, second, and third class, 95; luggage-vans, 28; goods wagons, 501—total, 624. It is proposed to increase the number of carriages to 160 as soon as the second line of rails is laid.

There is nothing further requiring special remark as to the construction or working of the Italian or Swiss railways, excepting matters of maintenance, &c., which will be treated under their respective headings.

FRENCH RAILWAYS.

French Railways. I had not much opportunity of studying the French system of railways; but the lines running out of Paris are well and substantially constructed. The gauge is 4ft. 8½in., and the carriages are very well fitted. The engines are of varied types, from six-wheel tank engines, used for suburban traffic, to the cumbersome goods engines, weighing 45 tons exclusive of the tender. The passenger engines are chiefly used with four wheels coupled, and both inside and outside cylinders are adopted for the express service. The average speed of the express trains is about thirty-five miles an hour excluding stoppages. There are over 13,000 miles of railway now opened for traffic. On the principal lines [L'Est, Nord, Paris-Lyon-Mediterranée] the "Vignole" or flat-footed rail is used, made of steel, varying in weight from 70lbs. to 85lbs. to the yard, with the joints fished over a sleeper, and the rails are fastened with spikes to the sleepers; and on three of the lines, viz.: the Midi, L'Orleans, and L'Ouest, the ordinary double-headed rail and chair is used.

Stations. The principal railway stations are very handsome buildings, furnished with waiting-rooms for each class of passengers, in which they must remain, after taking their tickets, until the doors leading to the platforms are opened. The guard invariably carries a horn, with which he gives his starting signal to the engine-driver; and the principal lines are worked on the telegraph block system.

Sleeping Cars. Pullman. Mann. Attached to the mail train running between Brindisi and Paris, *via* Bologna, are Pullman sleeping cars, which belong to, and are worked by, the Pullman Company of America; but on the trains running between Milan and Basle there is another description of sleeping car, or "wagon-lit," as it is termed, called the "Mann car." It is, in my opinion, more suited to the British travelling public than the Pullman, being fitted with compartments holding two or four passengers, as the case may be, and having a side passage running the full length of the carriage. The carriages used on the St. Gothard line, also the Pullman and the "Mann" cars are illustrated in the appendix hereto (Plates 2, 3, 4, 5, 6, and 7). The cost of the "Mann" car, as manufactured in Germany, is £850 f.o.b. Each car seats twenty-one passengers, is fitted with dressing-room, W.C., gas and heating apparatus, and is also trimmed with green velvet, and pannelled in mahogany and maple. A full description of the "Pullman" cars is given under the heading American Railways.

Plates 2, 3, 4, 5, 6, and 7.

ENGLISH RAILWAYS.

English Railways. I travelled from London to Bristol by the broad gauge (7ft.) express train, which is still running through to Exeter, although there is a standard gauge (4ft. 8½in.) *via* Gloucester. The travelling by the "express" leaves nothing to be desired—it is simply perfect, the motion is easy, and there is no perceptible swaying of the carriages, although the speed attained is at times sixty miles per hour. The

* To operate these turbines, there is of course a constant and abundant supply of water from the heavy rainfall in winter, and in summer from the snow melting on the mountains through which the tunnels are pierced.

The average speed of fast trains on the English Railways is about 46·2 miles per hour; on the French, 37·5 miles per hour; on the German, 40 miles per hour; and on the American, 37 miles per hour. Speed of fast trains.

The Midland Railway runs its fast trains at about 48 miles per hour, exclusive of stoppages
" Great Northern " " " 46 " "
" London and South-Western " " " 46 " "
" South-Eastern " " " 46 " "
" London, Chatham, and Dover " " " 44¼ " "
" London and North-Western " " " 44¼ " "
" Great Eastern " " " 44¼ " "
" Great Western " " " 44 " "
" London, Brighton, and South Coast " " 40 " "

In England it is everywhere conceded by those conversant with the construction and working of railways, that to lay down light permanent way in hilly districts where steep gradients must of necessity be used is the reverse of economy, because to work steep grades heavy engines must be used, and therefore a light permanent way would be inadmissable; but on level country a light road may be adopted where the traffic is limited, and where there are no steep gradients. Heavy permanent way on steep gradients.

There is not much in railway construction in England which is absolutely new, and very few improvements are introduced which are not adopted in the colonies.

The various methods of signalling trains, the appliances used at stations, the maintenance of permanent way, &c., will be dealt with under their respective headings.

In December, 1882, according to the Board of Trade Report, there were 13,052 miles of railways in England and Wales owned by 225 companies, only eighty-six of which controlled the working of their own lines. Twelve companies undertook the management of 10,854 miles, the most important being the Great Western with 2,239 miles.

In Ireland there were forty-one companies, having 2,465 miles, of which six companies had the management of 1,806 miles.

In Scotland there were thirty-one companies, having 2,940 miles, of which two companies had the management of 1,864 miles.

AMERICAN RAILWAYS.

There are in the United States and Canada at the present time about 128,000 miles of railway opened for traffic, and the main lines of railway in the Eastern States are well and substantially constructed. The "Vignoles" section of rail is universally adopted throughout the States, weighing from 60 to 70lbs. to the yard, and made of steel. The rails are secured to the cross sleepers by dogspikes, and the joints are fished and frequently laid on a sleeper. It is also the practice on some of the railways to break the joints of the rails, and not place them opposite to each other on the same sleeper. American Railways. Miles open. Rails. Joints.

The road beds are, on the main lines, well graded and drained, and are ballasted with stone or gravel, the rails being kept in good line and running order.

The Pennsylvania Railroad is acknowledged to be the best constructed and managed road in the States. The company owns and operates 2,047·5 miles, of which number the Pennsylvania Railroad.

Pennsylvania Division comprises	1,138·8 miles	Length.
United Railroads of New Jersey Division	490·5	
Philadelphia Erie Railroad Division	418·2	
Total	2,047·5 miles.	

This railway is managed by a president, four vice-presidents, a general manager, secretary, cashier, comptroller, auditors, two freight agents, general passenger agent, baggage agent, chief engineer, consulting engineer, engineer of bridges and buildings, general superintendent of motive power, two purchasing agents, a general agent at Philadelphia, a general agent at Pittsburg, a general agent at New York, and a superintendent of transportation, besides numerous passenger agents in the cities with which this railway is connected. Management.

The company has adopted the most modern appliances for signalling and interlocking switches yet introduced in the States. These have been perfected by the Union Switch and Signal Company of Pittsburg, and will be described under a subsequent heading devoted to this subject. Signalling arrangements.

On this line the rails are of steel, 60lbs. and 67lbs. to the yard (see Plate No. 8), 30ft. long, and are laid ~~to break~~ joints opposite to one another, as obtains in England, and are spiked on the inside and outside on every sleeper. The ballast, which consists of clean broken stone 2½in. gauge, is 12in. deep under the sleepers, and is spread up to the level, but not above the top, of the sleepers. The sleepers, or "cross ties," as they are termed, are 7in. by 8in. in section, and 8ft. 6in. long, and sixteen are spaced to each 30ft. rail on main lines, leaving 10in. between the two joint sleepers (see illustration in appendix). For branch roads and third tracks on main lines, used exclusively for freight trains, fourteen ties are used for each 30ft. rail; and for sidings and tracks used for standing cars only, not exceeding twelve ties are used. The gauge of this line is 4ft. 9in., or ½in. wider than the standard gauge in England. At road crossings planks are used for the roadway, securely spiked to the ties, kept three-quarters of an inch below the level of the top of the rails, and 2½in. from the gauge line, the ends and inside edges being bevelled off. The Plate No. 8. Joints. Ballast. Cross ties. Spacing. Gauge. Road crossings.

Specification—Steel rails.

The following specification is adopted for steel rails by this company:—

1. The steel used for rails shall be made in accordance with the "pneumatic" or "the open hearth" process, and contain not less than thirty or more than $\frac{4}{100}$ of one per cent. of carbon.

2. The result of the carbon test of each charge, of which the Pennsylvania Railroad Company is to receive the rails, and of which an official record is kept at each mill, is to be exhibited to the rail inspector.

3. A test bar, three-fourths of an inch wide, and ten inches long, is to be taken from a web of a rail made from each charge.

4. The number of the charge, and place and year of manufacture, shall be marked in plain figures and letters on the *side* of the web of each rail.

5. The sections of the rails rolled shall correspond with the respective templates issued by the railroad company, showing the shape and dimensions of the different rails adopted as their standard.

6. The space between the web of the rails and template, representing the splicebar, shall not be less than one-quarter of an inch, nor more than three-eighths of an inch.

7. The weight of rails shall be kept as near to standard weights as can be demanded after complying with section No. 5.

8. Circular holes one inch in diameter shall be *drilled* through each web in the centre thereof, at equal distances from the upper surface of the flange and lower surface of the head, and 3½in. from the end of the rail to the centre of the first hole, and of 5in. from the centre of the first hole to the centre of the second hole.

9. The lengths of rails at 60° Fahrenheit shall be kept within *one-quarter of an inch* of the standard lengths, which are 30ft., 27½ft., and 25ft. That not more than 10 per cent. of rails of the shorter length, nor more than 5 per cent. of No. 2 rails will be accepted on any one contract.

10. The rough edges produced at the ends of the rails by the saw shall be well trimmed off and filed.

11. All rails shall be straightened in order to secure a perfectly straight track.

12. The causes for a temporary rejection of the rails are:—

1. Crooked ends.
2. Imperfect ends, which, after being cut off, would give a perfect rail of one of the standard short lengths.
3. Missing test reports.
4. A variation of more than one quarter of an inch from the standard lengths.

13. The causes for a permanent rejection of a rail, as a No. 1 rail, are:—

1. A bad test report showing a deficiency or excess of carbon.
2. The presence of a flaw one-quarter of an inch in depth in any part of the rail.
3. A greater variation between the rail and splicebar than is allowed by paragraph No. 6.
4. The presence of such other imperfections as may involve the possibility of the rail breaking in the track.

By order,

WM. H. BROWN, Chief Engineer.

New York and Chicago, Limited, train.

The New York and Chicago, Limited, train, composed entirely of Pullman parlor, sleeping, dining, and smoking cars, is the fastest and best appointed train running between the Atlantic Coast cities and the West, and runs daily, without change, between New York, Philadelphia, Baltimore, Washington, and Pittsburg, Fort Wayne, Columbus, and Cincinnati. Between Pittsburg and New York this train runs 444 miles in 12 hours, and between New York and Chicago (912 miles) in 25 hours and 40 minutes. The running time of the limited express between New York and Philadelphia (90½ miles) is 2 hours and 25 minutes, and in travelling by the express between the two cities I have frequently timed the train running a mile in 56 and 58 seconds respectively.

Stations.

The stations (or depôts as they are called in the Sates) at Philadelphia and Chicago are fine structures, replete with every convenience; and recently the Pennsylvania Company has organised a line of hansom cabs which run in connection with the trains at the Broad-street Depôt, Philadelphia, and are found to be a very great convenience to travellers, who formerly had either to submit to the extortion of the drivers of the hack carriages or use the tramcars. It is the intention of the Reading Railroad Company to introduce the same system in connection with their depôts.

New York Central Railroad.

At the New York Central Depôt—another fine station—I was, by the courtesy of Mr. Dudley, the inventor of the dynagraph car, shown into the office of the "train despatcher," fitted up in the roof of the station, which is similar in design to that of the London and North-Western Company's station at Liverpool.

Train despatcher.

The office of train-despatcher is purely an American institution, there being no officer on the European Railways which corresponds with him. This officer has supreme control over the movements of every train and engine entering into or departing from the terminus, and effects his orders by electrical communication with the various offices. He controls the closing of the doors of the waiting-rooms leading to the platforms, stops the registration of baggage at the proper time, closes the ticket office, and signals the engines to back into and start the trains.

Starting trains automatically.

On a board fixed to his desk are certain ivory buttons, each bearing the name of the office or signal with which

which he wishes to communicate, all of which signals are replied to on a series of bells also fixed above the desk. The trains are signalled into and out of this station automatically.

Description of machines.

The machine for this purpose is made of brass, copper, and steel, occupying a small space—less than 2ft. square—and consists of three upright brass cylinders, in which are pierced a series of holes, each representing one of the 1,440 minutes of a day of twenty-four hours. On three pairs of pillars placed by the sides of these cylinders are fixed pins forming a spiral, and representing the twenty-four hours of a day. The three pairs of pillars as they stand represent respectively the three railways using the Grand Central Depôt, viz.—the Harlem, the New York Central, and the New York, New Haven, and Hartford lines. A series of springs connected with an electrical apparatus are so arranged that as each of the cylinders revolves during the twenty-four hours, these springs receive a certain definite movement at a certain definite time, the pegs fixed on the hour pillar and the movable pegs set in the minute-cylinders striking as they revolve the arms of the springs, and thereby set the proper bell ringing in the station. At twenty minutes before the time for the train to leave the depôt, bells ring for the gates to be opened; and fifteen minutes later they ring in the passenger waiting-rooms, warning "all aboard," and at the same time ring in the baggage-rooms, warning the baggage-master to have all the baggage booked taken to the train. At one minute before the departure of the train the bells ring to close the doors leading into the station, and a minute later to start the train. This work is entirely automatic, and is effected by clockwork and electricity. The machinery adjusts itself once in seven days for the fewer trains running on Sundays, and re-adjusts itself for the Monday and days following. There are 198 trains daily arriving at and departing from the station during winter (Sundays excepted, when there are only forty-eight), and in summer there are 230 trains arriving and departing on week days.

Pullman cars. Plate No. 2.

The Pullman cars (see Plate No. 2) are well known throughout the Continent of Europe and America, and although many of the large railroad companies make their own cars, yet by far the largest establishment for their manufacture is owned and controlled by the Pullman Palace Car Company, of which Mr. Geo. M. Pullman is the president. This company has shops for the construction and repair of rolling-stock at Pullman, Ill.; Philadelphia, Pa.; Elmira, N.Y.; Detroit, Mich.; St. Louis, Mo.; Derby, England; and in Italy.

Detroit, Ill., shops.

The Detroit shops are old established, and their capacity has been enlarged until in 1881 they turned out 114 sleeping cars, or about two cars per week. The shops are now farther increased, and at the present time the company employs a force of over 7,000 men, operates over 1,000 sleeping, parlor, and hotel cars, and carries on the construction and repairing of its stock at the places above mentioned.

Pullman works and city.

In 1880 Mr. Pullman conceived the idea of building works near Chicago, and with this object he purchased the necessary land; and the Pullman company, in conjunction with the Land Association, is now engaged in improving the surrounding property of 3,000 acres by draining, sewering, grading and macadamising the streets, laying on water and gas, and erecting houses for the workmen, as well as public buildings for the use of the employés.

The work of building these shops and forming the town of Pullman commenced in 1881-2, and, notwithstanding the severe winters, there exists to-day a prosperous city upon land that three years ago was nothing but a barren waste. The works are situated on the west shore of Lake Calumet, near Lake Michigan, and cover fifteen acres of ground, while many of the buildings are three stories in height.

Corliss engine.

The machinery is driven by the great Corliss engine, which formed the main feature of attraction in the Centennial Exhibition of Philadelphia in 1876. This engine weighs 607 tons, developes 2,400 horse-power, and cost £22,800. The steam in the boilers is generated with the shavings delivered from the wood-working machinery by means of a blower. The main driving shaft is 9in. in diameter and 600ft. long, from which all the machinery for the forges, foundry, and pumping is driven. The water pressure is obtained by pumping water into a tank in a water tower 200ft. high; and the same engine also pumps the sewage of the town to a farm three miles distant from the works.

Allen Paper Carwheel Works.

Mode of manufacture.

Just north of the main buildings are the Allen Paper Carwheel Works, where 400 workmen are employed, and 1,200 wheels can be annually manufactured. The process of manufacture is very simple, and consists of compressing, by hydraulic power, ordinary coarse brown paper pulp, containing a certain proportion of wood fibre, to such a density and solidity that it appears when turned to be similar to boxwood. The pressed material is then chucked in a lathe, bored and turned to gauge. It is next taken to another hydraulic press where it is forced into the cast-steel tire, and the centre or boss is forced in at the same time. Two plates of iron, one quarter of an inch in thickness, are then bolted one on each side through a web rolled inside the tire, thus forming a perfect wheel. These wheels are used exclusively by the Pullman Car Company upon their parlor and day cars, as well as upon their sleeping and dining cars, their cost being from £15 to £19 per wheel.

Cost

"Dixon" loose carwheel.

There is another kind of wheel used extensively under the Pullman cars, which is known as "The Dixon Loose Carwheel," which is a loose wheel with an inwardly projecting boss or hub, fitted to a large inner bearing or wheelseat, on a *revolving axle*, the inner bearing or wheelseat being larger by about twice the diameter of the outer journal.

Mode of action.

By this adjustment of larger and smaller bearings, the wheels when passing along a straight line, cause the *axle* to revolve in conjunction with the wheels on the small or ordinary end journals of the axle, while in passing round a curve, the wheel on the outer rail of the curve is made to revolve on its seat or larger bearing sufficiently, *and only so much as is sufficient*, to overcome the difference in length between the inner and outer rails of the curve described by the railway. The

Lubrication. The hub or boss is lined and faced with anti-friction metal, and the lubrication is constant and perfect. It is effected by means of longitudinal grooves cut in the axle and extending to and through the inner bearing or wheelseat, from the common outside oil axlebox of the car. The practical tests of this mode of lubrication have been abundantly proved. No modification of the ordinary wheel, truck, hangers, boxes, or other appendages are necessary, and only a slight change in the bore of the wheel to admit the insertion of a hub, and an enlargement of the shoulders of the axle, are required to adapt the ordinary wheel and axle.

This patent is adapted to the ordinary cast-iron chilled wheel, the wrought-iron wheel, or the paper wheel, and would no doubt be admirably adapted for tramcars when traversing the corners of streets.

Plate No. 9. The wheel and axle is illustrated in Plate No. 9 of appendix, where figure 1 represents a 42in. cast-iron wheel, fitted with the Dixon hub and axle, the right-hand wheel showing the inwardly projecting hub, and enlarged shoulder to which it is adjusted. In this figure, the hub is a wrought-iron cylinder, forced into the wheel by hydraulic pressure, with flanges shrunk on the inner extremity for shoulder bearing and to form a dust-guard.

Figure 2 shows this plan applied to a paper wheel (Allan's patent). Figure 5 is a plan of the Dixon axle, with enlarged wheel seat and oil duct. and figure 6 is a section of the Allen paper wheel, with the Dixon hub and axle.

Passenger and Freight Cars.

Plates Nos. 10 and 11. Harlan & Hollingsworth Car Co. section car. The sleeping cars illustrated in Plates Nos. 10 and 11, and manufactured by the Harlan & Hollingsworth Co. of Wilmington, Del., U.S.A., are constructed with twelve sections, to accommodate twenty-four persons, and are fitted with smoking-saloon, ladies' toilet-saloon, and water-closets at each end of the car. Some of these cars, suitable for long journeys, have a buffet in addition, which causes the cars to be of great length (over 71ft.), and necessitates the use of 6-wheel bogie trucks with 33in. wheels, steel tired. The cost of such a car, boxed and delivered at Philadelphia, would be about £2,400, and if with buffet added would be about £2,500, finished in walnut in the best style; but if the finish be less elaborate the cost would be reduced by £100 or £200. The weight is about 30 tons.

Buffet.

Cost.

Ten-section car. An illustration is also appended showing a ten-section sleeping-car, accommodating twenty passengers, and fitted with water-closets and retiring rooms; mounted on four-wheel bogie trucks with 36in. wheels, steel tired. These cars cost, boxed and delivered f.o.b., Boston, in the best style, about £2,100, and with less elaborate finish the cost would be reduced by about £200 or £300. The weight is about 27 tons.

Cost.

Gilbert Car Co. Plates Nos. 4, 5, and 6. The Gilbert Car Manufacturing Co. of Troy, New York, manufacture a sleeping car (Plates Nos. 4, 5, and 6), called the "Mann" car, in which the sleeping compartment is so designed that it is readily convertible into a parlor car. These cars are about 50ft. or 60ft. long, and cost from £2,600 to £2,800 each, boxed and delivered f.o.b., New York. This company also manufacture the sleeping-car known as the "Wagner" car.

Mann boudoir car. The "Mann" car manufactured in America is about 60 to 64ft. in length, and is built on a different principle to the ordinary sleeping cars. The trucks have 42in. paper wheels, tired with Krupp's crucible steel tires. The interior of the car may be thus briefly described:—At each end there is a vestibule, one for ladies, the other for gentlemen, with dressing-rooms, closets, lavatories, &c.; the vestibules are connected by a passage or corridor running along the side, and from the corridor doors open into the various compartments arranged to accommodate two or four persons. In the daytime these compartments contain one or two well finished sofas, with high backs, affording a good rest for the head, each sofa being fitted across the car, the space beneath being used for the mattresses and bedding. The weight is thus brought as near to the floor level as possible. At night the sofabacks, being hinged at the top to the cross partitions which separate the compartments, are lifted to a horizontal position, where they are securely retained, thus forming the upper bed, while the bottom of the sofa forms the lower bed. By arranging the beds across the car there is less motion felt, and as the head of the bed is placed close to the corridor partition, there is an absence of draughts which are a source of complaint in the ordinary sleeping car in which the traveller sleeps on beds placed longitudinally. The ventilating arrangements are perfect, the air undergoing a constant change without draught or dust.

Trucks.

Interior.

Day.

Night.

Buffet. Connected with the gentlemen's vestibule is a smoking-room and buffet, whence passengers can obtain a good breakfast, or luncheon, with wines, milk, tea, or coffee. Every compartment has an electric bell, by which the porter is called.

Deadweight. It is stated by the manufacturers that the deadweight of these cars per passenger carried is fully 15 per cent. less than that of the Pullman or Wagner palace cars. On and after March, 1884, this company will build cars on hire, and fit them up in a most luxurious manner. One of these cars, the Adelina Patti, designed by Colonel Mann for Madame Patti's use, was built for this purpose. A floor plan and elevation of this car is illustrated in appendix, Plates Nos. 4 and 6.

Car run on hire. Plates Nos. 4 and 6.

Standard box car N.Y. Central Plates Nos. 12 and 13. The standard box freight cars of the New York Central Railroad are illustrated in Plates Nos. 12 and 13, and serve to show the usual style of freight car used throughout the railway system of the United States. These cars are mounted on four-wheel bogie trucks, and weigh on the average about ten tons, and will carry ten tons of paying load. The illustrations in the appendix will sufficiently explain the construction.

Load.

Plate No. 14. Harrison's postal car. Plate No. 14 illustrates the system, in use on some of the main lines of railway in the States, of carrying and sorting the mails, and is the invention of Mr. Harrison, of Fond du Lac, Wisconsin. Having seen these cars at

at the Chicago Exposition, and had their merits explained to me by the inventor—who received a gold medal—I was surprised at the simplicity of the construction of the fittings of the cars and the great facilities afforded for dispatch combined with great economy in working. The car has been thoroughly tested on the western roads, and the merits claimed for the arrangements as compared with other postal cars are as follow:—

Advantages claimed.

1st. That the car contains more separations for mail, and more space for separations, and, at the same time, more storage room.

2nd. That more men can work in the car, and much more mail can be worked by each man, because the tables and racks are all in sections, portable and adjustable to any point, place, or grouping desirable, and the matter is thrown directly into the bag to be filled and tied, or locked out, and so is handled in piece and in bulk only once.

3rd. That the whole car floor is utilised as wanted, alternately for storage, for working mail, for clear space, alleys, or passage-ways, in any direction or part of the car. The tables drop or detach; part of the racks are simply portable, and each section, in whole or in part, may be knocked down or folded away and replaced in the same or different and more available order or relations to each other, and all a momentary operation.

4th. That this car is more conducive to health, comfort, and strength of the men, because the windows and doors, with all the space between them above the middle of the operator, are wholly unobstructed, giving free and full light, sight, and ventilation.

5th. That these cars are all less costly to build than those on the old plan, the patterns and devices being uniform and adapted to all classes of mail cars. The material is durable, easily fitted up and repaired; every joint, piece, and part can be at once duplicated, and will always fit in its place. This apparatus is adapted to "route agent cars," because the mail room is the full width of the car.

Postal bag racks for post offices.

These cars are adopted by the Government of Canada, and the postal bag racks are also used in the post offices at Chicago, Milwaukie, Minneapolis, Wheeling, Baltimore, Albany, Montreal, and Toronto. These racks are of iron or brass piping, and the drop tables of hardwood, from which the mails go direct to the bag, saving one handling and taking less time to "tie out;" consequently a mail can be kept open longer at each post office. The hooks are the same as those fitted in the cars, and any sized bag or pouch can be hung on them; the bags are dropped and tied without lifting. These bag racks are fully illustrated in the appendix, and are well worth a trial by the postal authorities of this colony.

Racks. Tables. Hooks.

Description of Plate No. 14.

Figure 1, Plate 14, shows the interior of a postal car, with the tables and supports detached, and the racks folded.

Figure 2 shows the interior of the same car, with racks in position and tables down.

Figure 3 shows the interior of the same car in full working order.

Figure 4 shows a ground plan of the interior of a 40ft. postal car in working order, fitted with bed, lavatory, water-closets, &c., &c.

Mail car lamps.

Figures 5 and 6 show an elevation and section of the mail car lamp and canopy hung from the roof of the car.

Figure 7 shows the mail car bracket lamp fixed to the sides of the cars. These lamps are a specialty manufactured by Adams & Westlake, Chicago.

Figure 8 shows a postal bag rack for 10 bags, 12in. by 12in.

Figure 9 shows a postal bag rack for 14 bags, 12in. by 12in., which costs, boxed and delivered f.o.b., £11.

Postal bag racks.

Figure 10 shows postal bag rack for 70 bags, 12in. x 12in.

Figures 11 and 12 show postal bag racks in perspective and plan for 92 bags, 12in. x 12in., in quarter circle sections on movable platform.

Standard passenger car trucks. Plates Nos. 15 and 16.

Plates Nos. 15 and 16 is an illustration of the standard passenger car truck of the Pennsylvania Railroad and the Lehigh Valley Railroad.

Metropolitan Elevated railroad, New York. Plates Nos. 17, 18, & 19.

Plates Nos. 17, 18, and 19, illustrate the cars used on the Metropolitan Elevated Railroad of New York. These cars are specially constructed to traverse any sharp curves, and are made with radial end platforms and draw bars radiating on a pin immediately above the main king bolt of the bogie trucks in sectors secured to the body. Each car has side platform gates at both ends, and between the platform post of each car is a movable lattice work which expands and contracts when running round the curves, the object being to prevent persons from stepping off the station platform on to the cars, thus avoiding accidents. This plan could be adopted between the ends of ordinary carriage stock and would to some extent prevent persons from falling from the station platform over the buffers on to the line.

Platform gates and lattice connection between cars.

Flat cars. Plate No. 20.

Plate No. 20 is an illustration of the arrangement of stanchions adopted by some railroad companies on flat cars.

Stock Cars.

Stock cars. Plate No. 21.

These are illustrated in Plate No. 21, and fully described under Part No. 7, "Sheep and cattle trucks," &c.

Drawbars and Couplings.

Drawbars.

The drawbars used on many of the railways in the States are open-mouthed bars, into which coupling-links

links are inserted, and secured by a pin. They are usually provided with springs for tension as well as for compression.

Bolt drawbar. There are several kinds in use, viz. :—The bolt drawbar is used on freight cars generally.

Centre draft. The centre draft drawbar, which is attached to the kingbolt of the bogie and car, in the manner illustrated in Plate No. 18 of the passenger cars used on the elevated railroad of New York.

Continuous. The continuous drawbar, which is connected at each end of the car by a rod running longitudinally, and secured to each drawbar.

Potter. The Potter drawbar, sometimes called the three-link drawbar, which is made with a pair of ears on each side. To one pair a link is fixed, and to the other pair and to the centre other links can be coupled.

Safford. The Safford drawbar, the heads of which are constructed in such a manner as to leave room when they are in contact for a man's hand to be inserted for coupling or uncoupling.

Spring pocket. The spring-pocket drawbar, which is constructed with an opening or pocket in the rear end, into which the drawspring is placed.

Miller automatic coupling. The "Miller" drawbar and coupling-hook, which is used chiefly on passenger cars, and by which cars can be coupled automatically. It consists of two heavy iron hooks, which, acting as drawbacks, are made to engage with each other by two springs when the cars come together.

One great desideratum gained by this coupling is that the cars are always tightly coupled, and the swaying of the carriage-bodies on the bogies is minimised.

Janney automatic coupling. The "Janney" coupler, used for passenger and stock cars, also couples automatically. The outer end of the drawbar is made forked or U-shape; and to one arm an L-shaped knuckle or clutch is pivoted, so that when the two drawbars come together the two knuckles engage into each other. There is also a buffing arrangement, one buffer being on each side of the drawbar.

Buffer.

Car Wheels.

Cast-iron chilled car wheels. The car wheels used on nearly all the passenger and freight stock in the United States are made of iron cast in chills and annealed. These wheels are usually made from pure Salisbury charcoal iron. They are much cheaper than wrought-iron wheels, weigh about 480lbs. for a 33in. wheel, and run about 160,000 miles before being thrown aside as scrap for remelting and mixing with new ore for casting new wheels. They are admirably adapted for severe climates, where the frost acts so disastrously upon steel tires; and being cast as a complete wheel, with the tire already formed, there is no danger to be apprehended from tires being fractured and flying from the wheel. I saw some of these wheels being made, and it was surprising to see how accurately they were cast, and how well they were balanced. From a published table of tests made by W. W. Evans, Esq., C.E., of New York, upon six of these wheels, at the shops of the New Haven Railway, it appears that the greatest variation from a true circle, taking careful measurement every eighth of an inch round the whole wheel, was from 1-28th to 1-64th of an inch. The wheels only required from 0·44 to 1·94lbs. to balance them when running on Y bearings.

Tests as to accuracy in casting.

Delivery and ~~Running~~ Receiving Apparatus for Mails.

Plate No. 22. Picking up and dropping mailbags. The mode of picking up and dropping the mailbags at stations where trains do not stop is illustrated in appendix, Plate No. 22, and is of very simple character, and consists of a bent iron bar attached to the door of the mail or postal car by which the bags are taken off the projecting arms of the post or crane at the station. It is an invention known as "Ward's Patent Mailbag Crane and Catcher," and is used on the main lines of railway in the States. Plate 22A illustrates an ordinary mail and baggage car.

Ward's patent.

Plate No. 22A.

Coaling Locomotives.

Plate No. 23. Kerr's patent coal chute. The main lines use an appliance for coaling similar to that illustrated in appendix, Plate No. 23, and known as "Kerr's Patent Coal Chute," by means of which the coals are tipped direct from the cars into the chutes, which are graded, so that all the coal is measured for each engine taking coal, to enable a correct account to be taken. It is said that they are more economical than sheds with derricks and buckets, and that nine-tenths of the time consumed in coaling by the ordinary system is saved.

New York, Lake Erie, and Western Railway. I saw at the Chicago Exposition a model of the coal chutes or pockets, as used on the New York, Lake Erie, and Western Railroad (Susquehanna Division).

Capacity. These pockets hold about 350 tons of coals. The arrangements are similar to those described above so far as the inclined approach is concerned, but the pockets are built in a framing of timber carried on piling; and upon the top of this framing rails are laid for the coal cars to traverse. Each car is on the hopper bottom principle, and holds twenty tons of coals. About half a dozen trucks are shunted up the incline on to the staging, when the coal is dropped into the pockets, which may be single or double, as required. From these pockets the coal runs down inclined planes into the measuring pockets, each holding about two tons. These measuring pockets are controlled by levers operating hinged and counterbalanced iron doors.

Coal cars.

In other places the coal drops from the coal cars into a receptacle, from whence it falls through suitable openings into small wagons, in which it is weighed, run out to the side of the stage, and tipped into the tenders.

At Susquehanna the coal is delivered into the small wagons from the receptacle above mentioned, but these wagons have hopper bottoms, and hold about two tons, and when a tender requires to be filled these wagons are run out on to a counterbalanced platform, which is lowered by means of chains and friction pulleys, and the coals are tipped into the tenders. Counterbalanced platform.

The time occupied in loading a tender is about one to one and a half minutes for each two tons. The engines take from three to six tons of coals at a time. Time in loading tenders.

The system of storing coal in bulk, and arranging pockets at such an elevation that the coals will slide into the tenders, seems to be much in favor on the railways of the United States.

Locomotives and Rolling-stock Generally.

Throughout the whole of the United States and Canada the American pattern of locomotive is universally adopted, and the types used are few in number. The engines are built on certain designs known to all the railway authorities, such as the "American" pattern for passenger service, the ten-wheeled type for mixed traffic, and the Mogul and Consolidation patterns for freight service on the standard gauge. Locomotives. Types.

The "American" passenger engines have usually four wheels coupled, having a four-wheeled leading bogie truck, and cylinders 10in. to 18in. diameter, with stroke 20in. to 24in. American.

The mixed traffic or ten-wheeled type engines have usually six wheels coupled and a four-wheeled leading bogie truck, and cylinders from 16in. to 19in. diameter, with stroke 24in. Ten-wheel type.

The "Mogul," or freight engines, are usually six-wheeled coupled, with a pony bogie truck, and swinging bolster in front; cylinders from 12in. to 19in. diameter, and stroke from 18in. to 24in. Mogul.

The "Consolidation" engines have usually eight wheels coupled, with a pony bogie truck in front, and cylinders from 20in. to 21in. diameter, and stroke from 24in. to 26in. These engines are built either with the front and rear, or main and rear driving wheels with flanges, the other pairs having wide tires without flanges. The weight of the heaviest class of this type is about 48 tons or 49 tons, having about 42 tons available for adhesion. Consolidation. Weight. As the manufacture of locomotive engines has attained very large proportions in the United States, a reference to the principal works will be interesting. There are several large works in the States where locomotives are manufactured; but many of the railroad companies make their own engines, the Pennsylvania Railroad Company having, at Altoona, the largest and best regulated shops of any railroad company in the States. The principal works are the Baldwin locomotive works, Philadelphia; the Rogers Paterson, New Jersey; the Danforth locomotive works, Paterson, New Jersey; the Grant Company, Paterson, New Jersey; W. Mason, Taunton, Mass.; the Brooks locomotive works, New York; and the Rhode Island locomotive works; but it is generally conceded by railroad engineers that the Baldwin and Rogers companies head the list, the former company having by far the larger premises—upwards of nine acres, and turning out more locomotives per annum than all the builders in New Jersey combined. Baldwin and Rogers. Baldwin works. The Baldwin Company has in fact built since 1831 (the date of the foundation of the establishment) 6,831 locomotives, and has, during the year 1882, produced 563 engines, and employed 2,900 men and 915 machine tools continuously in their construction.

The "Rogers" locomotive and machine shops are situated in Paterson, New Jersey, and have been established many years. Rogers works. There has been turned out of this factory 2,926 locomotives up to the close of 1881, in which year the output was 240. These works from 1856 to 1881 were under the immediate management of the late Mr. Wm. Hudson, one of Robt. Stephenson's apprentices, who was considered one of the most accomplished locomotive mechanics in his day.

The "Grant" locomotive works are also situated in Paterson, New Jersey, close to the "Rogers" works. Grant works. This firm has built since 1849, 1,559 locomotives, and turned out, in 1881, 111 engines.

The "Danforth" locomotive and machine works are in Paterson, New Jersey, having been in existence since 1837, and the number of locomotives turned out from that period to the end of 1881 having been 1,286, and during that year 106 locomotives. Danforth works.

Paterson is a very busy city, having been a centre of the locomotive building trade since 1837, and the number of engines built at the various establishments there up to the end of 1881 has been 5,871, or about 1,000 less in number than the total output of the "Baldwin" works. City of Paterson.

It is estimated that at the close of 1881 there were 23,929 locomotive engines built and running in the United States, of which New England possessed—1,700; Middle States, 6,000; Western States, 7,800; Southern States, 1,800; Pacific States, 420; Massachusetts County, 968; Pennsylvania County, 2,700; Illinois County, 1,900; Georgia County, 303; Virginia County, 300; Florida County, 38. Total, 23,929 locomotives. Number of locomotives in America.

I am indebted to the author of a valuable work on the History of Industrial Paterson (Mr. Trumbull), in which history the silk, cotton, flax, locomotive, iron, and miscellaneous industries are described from their inception to the present date. History of industrial Paterson.

That the American design of locomotive is a good one must be acknowledged, from the fact that it is universally used in a country owning upwards of 113,000 miles of railways, as well as in Canada, where the railways are chiefly in the hands of English capitalists and shareholders. The design of the American locomotives. It has been asserted that the American locomotives are short-lived, and are not economical in duty; but it seems incredible that such statements can be received as trustworthy, because the American railway men as a rule strive after the greatest economy possible, both in first cost and in maintenance on their lines. Indeed it is absurd to think that a people usually credited

credited with knowing what they are about should be so blind to their own interests as to use machines that require constant repairs, or materials which must require constantly to be replaced, especially when it is known that many of the leading lines are running in close competition for traffic, and would avail themselves of every means by which a reduction in working expenses could be effected. It is also necessary to remember that the experience of the American locomotive engineer is very great, that he has given the subject the most careful study, resulting in the production of a machine, that in the country where it is made, performs satisfactorily the work allotted to it, with the least amount of injury to itself or the road on which it travels. This is illustrated by the fact that its maximum life is about thirty years, the annual cost of repairs being from 10 to 15 per cent. of the first cost.

Elasticity. One peculiar feature in the construction of American locomotives is their elasticity both in running round curves and in enabling them to travel over rough roads with ease at a high speed where an engine of the European type, with its long and *rigid* wheel-base and *independent* springs, would with difficulty be kept on the rails.

Lateral flexibility. The lateral flexibility necessary to enable the locomotive to pass round curves with facility is accomplished by the introduction of a swivelling truck at the leading end of the engine. As soon as the engine passes from a straight line into a curve the truck swivels, and at the same time slides laterally just sufficiently to allow the frames to remain as tangents to the curve; and when the driving wheels strike the curve the truck changes its position, and the axles run radially with the curve. To prevent any tendency that might exist for the truck to leave the rails, an equalising bar is used to distribute the weight equally on the truck wheels. On some of the express engines outside and inside bearings or journals and double-equalising bars

Vertical flexibility. are used, so that a great speed can be maintained on a curved road. Vertical flexibility is attained by equalising bars applied to all the engine wheels, which thus receive their proper proportion of weight, and at the same time the entire adhesive power of the engine is made available, thereby keeping the tension on the springs as nearly uniform as possible. By this means the engine is rendered easy on the road.

In the "Mogul" type the pony truck is equalised with the leading drivers, and the main and trailing wheels with each other, thus giving great freedom of motion without undue strains.

Frames. The frames are always made open, and are composed of bars joined by welding and by bolts where necessary. They are extremely strong, very stiff laterally, easily made, and at the same time durable. The European type of plate-frame is never used on American locomotives, as it is said to enclose the machinery too much, and to increase the expenses of cleaning, as well as possessing a tendency to flexibility sideways, which is objectionable. The bar-frame reduces the cost of repairs on account of the facility with which the working parts are accessible. The first cost of a bar-frame is greater than that of a plate-frame; but the advantages gained by the former compensate for the increase in price.

Cylinders outside. Outside cylinders are almost universal. They are bolted together in the centre, and form a seat for the smokebox and forward end of the boiler, and are interchangeable from one side to the other. By the use of outside cylinders, crank-axles and their disadvantages are avoided, and most of the working machinery is placed outside the frames, where it is easily inspected and repaired without getting under the frames, and can be cleaned with the least amount of labor. The disposition of outside-cylinder engines to oscillate is minimised by properly balancing (a point most carefully attended to) and by the equalising levers before referred to.

Cab. The whole of the appliances necessary for working the engine are placed inside the cab within easy reach of the engine-driver, who is not required to leave it to oil the cylinders or other working parts.

Engine wheels. The wheel frames are usually made of cast iron, with hollow spokes and rims, and tired with steel forced on with an hydraulic press. These wheels weigh very little more than a wrought-iron wheel and have no welds to break, and are much cheaper to make. Cast-iron wheels have been used on some of the goods engines of the London and North-Western Railway of England for the past seven years, and Mr. Webb, the locomotive superintendent, has fitted up several engines recently with cast-steel wheels.

Bogie-truck wheels. The wheels used on the engine bogie trucks are usually of chilled cast iron, similar to those used on passenger and freight cars, and varying in diameter from 20in. to 36in., but never exceeding the latter. Spoke wheels with steel tires are also used on many engine trucks.

Tenders. The tenders, or tanks as they are termed, are generally mounted on bogie trucks as opposed to the European practice of having a rigid wheel-base. Some builders place a six-wheel truck under the rear end to support the greatest weight, and a four-wheel truck under the front end; others carry the rear truck close up to the back of the tender and thereby equalise the weight. The tender trucks, as a rule, have side-bearings under the rear end and a centre bearing under the front end.

Performance of American locomotives on New York Central and Hudson River Railroad.

Express service. I append a statement of the performance of some American locomotive engines working on the New York Central and Hudson River Railway, which certainly indicates that these engines are quite equal to excessively hard work. This railway runs along the edge of the river, and has a rock bed for the greater portion of the distance, and for seventy miles of the line has a large number of sharp curves. The express service is performed by doubling the ordinary mileage for two days and then laying up the engine for one day in order that it may be overhauled. The enginemen run from New York to Albany and back, about 280 miles. They are paid a day's wages for every 100 miles, say for the first 100 miles, and then 4 cents for every mile afterwards.

Statement. The following is a statement of five consecutive years' service of locomotives Nos. 10, 33, and 34, on the Hudson River division, given to Mr. W. W. Evans, C.E., of New York, by Mr. Wm. Buchanan, chief engineer

engineer of motive power. The engines were new when they commenced to run, and have been used on passenger trains only. Their dimensions were as follows:—

Dimensions of Engines, &c.

Cylinders, 17in. x 24in.; driving wheels, 69in.; steel fireboxes; semi steel tubes; weight in running order, 70,500lbs., or about 31 tons; weight on driving wheels, 44,850lbs., or about 20 tons; average speed, 38 miles per hour; date, from September 30th, 1877, to September 30th, 1882.

Average trains consist of—

Two baggage and mail cars loaded		52 gross tons
Two drawing-room or sleeping cars loaded		64 "
Five first-class passenger cars loaded		125 "
One engine	31 tons	
One tender half loaded	22 "	
	—	53 "
Total train loaded		294 gross tons

	Locomotive No. 10.	Locomotive No. 33.	Locomotive No. 34.	Average of all three.
Total mileage in five years	415,790	440,654	392,043	416,162
Number of days in service	1,495	1,565	1,430	1,496
Number of days idle	306	242	397	315
Actual months in service	59	58	57	58
Average miles run per month	7,047	7,597	6,878	7,174
Average miles each service day	278·12	281·57	274·15	277·95
Average miles run per year	83,158	88,131	78,409	83,233
Miles per year rated at miles per service day for 365 days	101,513	102,773	100,065	101,450
Gallons of oil used	2,882	3,337	3,027	3,082
Average miles run per gallon	144·27	132·05	129·51	135·27

Value in English money.

	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Total cost for oil	236 8 0	273 12 0	248 4 0	252 14 8
Total cost for waste	48 0 0	46 8 0	46 0 0	46 16 0
Total cost for labor on engine	813 7 0	896 1 0	868 15 0	859 7 8
Total cost for labor on tender	57 4 0	89 11 0	76 0 0	74 5 0
Total cost for materials on both	643 13 0	833 9 0	724 5 0	733 15 8
	d.	*d.*	*d.*	*d.*
Average cost of labor and materials used in repairs per mile run	0·87	0·98	1·02	0·96

Cost of American Railways.

Cost of American railways.

According to a statement prepared by two French engineers (MM. Lavoinne and Pontzel), who visited America for the purpose of inquiring into the construction and working of American railways, "the total "amount expended in the construction of the lines up to the end of 1875 was £949,929,000, and repre- "sented a cost per mile averaging £12,726. The average cost per mile of the two Transcontinental Pacific "lines up to the same date was £23,700 and £22,350 respectively, and the average expenditure on some of "the other lines was considerably in excess of these amounts, viz.:—

Transconti-nental Pacific.

Name of Railway.	Length of line.	Average cost of construction per mile.
		£ s. d.
Delaware and Lackawanna	190 miles	28,660 0 0
New York Central and Hudson River	608 "	31,050 0 0
Erie	214 "	44,440 0 0

The "Pool" System.

Pool system.

There is a system prevailing in America with regard to the distribution of traffic between various competing companies termed the "pool" system, by which certain rates are agreed to, and the profits divided; and this applies either to the whole of the traffic in the same direction or to special lines of goods. "A syndicate of this kind was established on the 15th December, 1878, in New York, comprising thirty- "eight railway companies having concessions on all the lines leading from the west and north-west to the "Atlantic shores. One of the most successful financiers, Mr. Jay Gould, has in his own hands 7,762 miles "of railways, and Mr. Vanderbilt also controls a very large mileage in a similar manner, and each has "succeeded in evading any interference or control on the part of the public authorities."—*Economiste Français*, March 6th, 1880.

Elevated Railroads in New York.

Elevated railroads, New York Systems of construction.

One of the most extensive systems providing for the transit of passengers in New York is that of the elevated railroad which traverses several of the principal avenues of the city. The systems of construction are

are varied, and an opportunity has been afforded of deciding upon their relative merits. In some portions of the lines which were first built, the posts or columns carrying the railway are single, built of channel and angle irons, connected by lattice-bars, and canti-levered out to carry a pair of longitudinal girders, to which the cross-sleepers are bolted. On other portions the Phœnix column is used, bolted to a cast-iron bedplate 4ft. square, secured to heavy brick or concrete foundations; while, in some streets, on the more recently-constructed lines, there are two columns placed one on each side of the street in a line with the kerbing, connected together with cross lattice-girders, upon which the longitudinal girders are placed; and in other streets the piers, consisting of two transverse columns, are fixed along the centre of the street. Nearly all the girder-work on the New York Elevated Railroad Company's line is riveted, the longitudinal girders being of the Warren type, but with riveted connections; on the other hand, the Metropolitan company have adopted the pin-connected longitudinal girders and riveted cross-girders. The rails are, on the average, about 18ft. to 20ft. above the street level, and the columns are spaced about 20ft. centres longitudinally, being so arranged as to interfere as little as possible with street traffic. The track is double. The curves are, in some instances, very sharp, being 110ft. radius (under two chains). The rails are of steel, weighing 60lbs. to 65lbs. to the yard, laid to a gauge of 4ft. 8½in., secured to the sleepers, which are 6in. square and spaced 24in. centre to centre. The curves are guarded with steel guard rails, spiked inside the inner rail, and longitudinal guard timbers are laid throughout the entire length of the line, these timbers being bolted to the cross sleepers, which are in their turn bolted to the iron girders. A plank footway is laid outside the track to allow the platelayers to traverse the line. The stations are built on a level with the rails, and are easily approached by iron stairways. The buildings are ornamental, and are supported on iron columns. The fare is universal, viz., 10 cents for any distance; and in passing from the top of the street stairway to the platform you purchase a ticket, which, as you enter the platform, you must deposit in a glass receptacle standing in the centre of the doorway leading to the platform. This is done in the presence of one of the railway porters, whose duty it is to see every ticket deposited, so that fares are not collected in the carriages, and a passenger does not keep possession of his ticket for more than half a minute at the outside before he parts with it finally. The ticket-box can only be opened by the officials authorised for the purpose. As soon the passenger steps into the car, the conductor closes a wrought-iron gate across the platform entrance of the car until the train arrives at the next station.

Posts.
Plate No. 23x.
Girders.
Rail-level.
Curves.
Rails.
Sleepers.
Curves.
Guard rails and guard timbers.
Stations.
Fares.
Plate No. 23y.
No ticket collectors.

The cars travel very easily round the sharp curves, and are well built, some being fitted with longitudinal seats with the seat for each passenger separated from the next one by a neat nickel-plated arm rest. Diagrams of these cars are given in Plates Nos. 17, 18, and 19.

Cars.
Plates Nos. 17, 18, & 19.

The Elevated and Metropolitan companies leased their lines in 1879 to the Manhattan Company under whose direction the lines are now running. The locomotives used are tank engines of the "Forney" type, with outside cylinders, and four wheels coupled, and a four-wheel bogie. The cylinders are from 10in. to 11in. diameter, and 16in. to 18in. stroke; wheels, 37in. to 41in. diameter; wheelbase of driving wheels, 5ft.; total wheelbase, 16ft.; weight, 32,000lbs. to 36,000lbs. The four-wheel truck enables the tank capacity to be increased and the engine to ride more smoothly on the track as the two systems of wheels are equalised. The fuel used is coal, and it is not found to cause any nuisance to the passengers. The trains consist of two, three, and in the morning and evening, as many as four long cars, which run at an average speed of about fourteen to fifteen miles an hour.

Manhattan Railroad Company.
Locomotives.
Fuel.
Trains.
Speed.

The number of passengers carried during the year ending September 30th, 1883, on the New York elevated railway was 55,019,901, and on the Metropolitan elevated railway was 37,104,916, or a total for the year of 92,124,807 passengers. There are upwards of thirty-five miles of elevated road in operation, 165 stations, 360 engines, and 625 cars. I could not obtain any records of the cost, but the minimum estimate was £40,000 per mile of single line, which must have been greatly exceeded.

Number of passengers carried.
Cost.

It is stated that in the broader avenues traversed by these railways business has not been affected, although the value of property must have to some extent deteriorated in consequence of the nuisance caused by the frequent running of the trains.

Business not much affected by railway.

In some of the narrower streets in the busy portion of the city the railway occupies the whole width of the street between the footpaths, and the damage to the properties has been severely felt by the owners, who, I understand, have sought in vain for redress.

Property in narrow streets deteriorated in value.

From my short experience as a traveller on the underground railway system of London and the elevated system of New York, I much prefer the latter to the former.

Altoona Works.

After leaving New York and Philadelphia I visited the works of the Pennsylvania Railway Company at Altoona, to which I have previously alluded. These shops are under the control of Mr. Eley, the divisional superintendent of motive-power, by whose courtesy I was enabled to see the works, which are the largest of their kind in the United States, employing upwards of 5,000 men. The works are well laid out, and every modern mechanical appliance has been introduced. The company build their own engines, and the arrangements for this work are very perfect. The erecting shop, which is 350ft. long by 135ft. broad, has three lines of rails running from end to end, and has overhead travellers, worked by wire ropes running the length of each 66ft. span of the roof, as well as vertical travelling cranes (worked also with ropes), which travel the length of the building, and are chiefly used for picking up cylinders or wheels and other heavy portions of the engines. The tools throughout the shop are of the very best type, chiefly of American manufacture; but I also noticed several very fine English tools. The

Altoona workshops.

The wagon-shop is semi-circular, having forty-four roads converging towards a turntable 75ft. diameter, driven by steam. There are various large shops used for building and repairing carriage and wagon stock, the storage of timber, and machinery for wood working. Wagon-shops.

The greatest care and attention are paid to the perfection of every article, not only manufactured but obtained from contractors; for which purpose an analytical chemist and assistants are engaged in a laboratory specially fitted for the purpose of testing all steel, iron, oil, copper, and other articles used, not only on the works, but upon the whole of the railway system of that division, such as rails, axles, tires, steel plates for boilers, and plate and other iron required for building the bridges on the lines. The bridges are all designed by an engineer (Mr. Jos. M. Wilson), whose special duty it is to attend to these structures. Analytical chemist. Bridge engineer.

Round Houses.

At nearly all the locomotives depôts which I visited in the States, the running sheds in which engines are stalled are segmental or circular buildings known as "round houses"; and this system seems to be preferred to any other, because, in the first place, such buildings occupy less space where ground is valuable; and, secondly, because the enlargement of a building to accommodate four engines to a size capable of holding thirty or forty engines is a very simple matter, and is effected as the demand arises. There is also a turntable placed in the centre of the circle from which the lines in the roundhouse radiate, and this is worked either by hand or steam-power. Round houses.

The same system is introduced at the Derby workshops, on the Midland Railway in England, which are acknowledged to be the best designed shops in the kingdom. At Derby there are at present three round-houses, and preparations are made for building four more. See Plates Nos. 23A, 23B. Derby shops. **Plates Nos. 23A, 23B.**

Train Indicators.

At the principal stations train indicators are fixed in the waiting-rooms (see Plate No. 23c, in appendix), by which the public are at once made acquainted with the time the next set of trains leave the station, and the names of the stations at which each of the trains stop or pass. This contrivance saves the passenger the trouble of asking, and the porter the trouble of replying to, questions connected with the departure of the trains. **Plate No. 23c.** Train indicators.

At the Chicago Exposition I inspected an indicator, made by the Wheeler & Wilson Manufacturing Company, on Mr. Boynton's patent. This machine worked somewhat upon the principle of the Jacquard loom, and exhibited the time at which each train would start on the six dials placed round the machine. Under each dial the name of the station is printed, and by sliding in one or any number of perforated cards the names of those stations only at which the trains were timed to stop would be visible to the public. All that is required is to have a set of cards prepared to correspond with the timetables, and insert them at the bottom of the panel under each dial, when the wire connected to a particular station label will fall into the required position, and so indicate the stations at which the particular train will stop. Boynton indicator.

Constructing Timetables.

When in San Francisco, at the office of Colonel Grey, the Engineer-in-Chief of the Southern Pacific Railway, I was shown the mode in which the timetables are constructed, and the diagrams finally drawn. Constructing timetables.

On a large drawing-board about 4ft. square a sheet of paper is stretched, and a line drawn along the *top* of the paper is divided into spaces representing twenty-four hours, each hour being divided into sixty minutes; while down the *left* hand side another line is ruled, and divided into miles and quarters. Intersecting vertical and horizontal lines are then drawn from these divisions, the vertical lines representing time and the horizontal lines distance. At the proper mileage of every station a firmer line is drawn. Needles are then fixed along the upper line at the exact time at which each train is intended to leave the terminus, and colored silks are used to connect these needles with other needles placed on the bottom line, which represents the arrival station, when, at a glance, the exact time of any train arriving at, or crossing another at, any particular station or siding can be seen, and, by using different colored silk, goods, passenger, or special trains can be laid down and adjusted until the proper time required for the arrival or crossing other trains at any given station is attained.

As soon as the whole service is adjusted pencil lines are drawn, and the timetable is written out for printing; at the same time any additional special train can be mapped out, and the time of crossing other trains at stations can be ascertained without any trouble. The diagram can be lithographed, if required, and the board used for another series, or the board can remain as a record in the office for reference. In the United States the boards are kept in the train despatcher's office for his use in lieu of the timetable.

Track or Rail Laying.

The rapid manner in which the rails are laid upon the lines of railway in the States has developed several plans for this purpose; but before describing them I will refer to the fact that over 4,000 miles of railway have been laid during nine months of the year 1883. It appears that 11,600 miles of railway were projected Track laying. Number of miles laid in 1883.

projected in 1882. The following table has been compiled, and was published in the *Railway Age* at Chicago, in October, 1883, and will be found interesting:—

Track laid from January 1st to September 30th, 1883.

State.	No. of lines.	Miles.	State.	No. of lines.	Miles.
Alabama	3	129	Minnesota	5	35
Arizona	2	155	Mississipi	6	226
Arkansas	6	97	Missouri	5	84
California	2	227	Montana	2	251
Colorado	3	41	Nebraska	2	44
Dakota	6	288	New Jersey	1	5
Florida	7	101	New Mexico	3	81
Georgia	7	64	New York	8	307
Idaho	2	210	North Carolina	1	12
Indian Territory	2	12	Ohio	13	195
Illinois	10	150	Oregon	3	65
Indiana	5	127	Pennsylvania	19	296
Iowa	7	69	South Carolina	2	28
Kansas	3	42	Tennessee	4	30
Kentucky	4	61	Texas	6	53
Louisiana	6	161	Utah	2	160
Maine	4	15	Virginia	4	58
Maryland	1	11	Washington Territory	1	44
Massachusetts	3	17	West Virginia	4	45
Michigan	7	142	Wisconsin	9	106

Total in 40 States and Territories, 190 lines, 4,244 miles.

In 1882 8,075 miles of track were laid on 260 lines, but none of the above figures include the thousands of miles of railways built in 1883 in Canada and Mexico.

Harris's system.

One of the systems in use is that patented by Mr. George F. Harris, of 71, Broadway, New York, which consists of a train of flat trucks, upon which rails are laid throughout the length of the train. The front cars are used for carrying the rails, and the rear cars for the sleepers. Upon the rails is placed a car called the "Automatic" car, which, on reaching the end of the train, unloads itself. There is also a car termed the "Pioneer" car, which is always in front of the train when it is being discharged. This car is built with an overhanging platform, and is carried on one four-wheeled bogie, its use being to carry the automatic car beyond the last length of rails before it unloads itself. The rails are run forward from car to car on iron rollers fixed along the centre, sliding on an incline from the end car of the train upon frames having anti-friction rollers.

Where used.

This system has been used for laying over 500 miles of line, and was adopted on the Wheeling and Lake Erie; St. Louis, Jerseyville, and Springfield; and Chicago and Atlantic lines, and is now in use on the Central Ontario of Canada; Rochester and Pittsburg; and the New York, West Shore, and Buffalo lines of railway.

Moore's system.

Another system is patented by the Moore Railway Construction Company of Chicago, whereby a special device is attached to the side of the cars, by which the sleepers and rails are conveyed along an inclined plane to the end of the road, where they are placed in position by the platelayers, with the assistance of a derrick overhanging the end car. It is claimed that from one to two miles of road can be laid daily,

Where used.

no special arrangement of cars being required. The Chicago and Alton; Chicago and North-Western; St. Paul, Minneapolis, and Omaha; Union Pacific; Illinois Central, and several other railway companies have adopted this device.

As an example of the work that can be done, and is frequently performed by a perfectly organised force, I will cite an example given by Mr. W. M. Johnson, Temple, Bell County, Texas, from his actual experience, as published in *Engineering News*.

Organisation for Laying one mile of Railway per diem.

Organisation for laying one mile of rails per diem.

For handling the sleepers, thirteen men and one water boy are required.

For handling the rails, eleven men and one water boy.

The front gang consists of thirteen men and one water boy.

The sleeper loaders—sixteen men in four gangs of four each, and one water boy.

The backspikers—fifteen men and one water boy.

The lining gang—five men and one water boy.

The back fillers—fifteen men and one water boy.

On the tool-car there is one man and a water boy to take care of and repair picks, shovels, mauls, &c.

Making a total number of eighty-nine men, eight water boys, seven foremen, besides eighteen teams, used as follows:—Sixteen for hauling sleepers; one for pulling the rail-car; and one for hauling water to the train camp.

At the teamsters' camp there is a foreman, a blacksmith, and night watchman.

The expenses are as under—

Cost per diem.

	$	£	s.	d.
1 Manager per working day	5·00	= 1	0	6
1 Bookkeeper	4·00	0	16	5
7 Foremen, @ $3·00 each	21·00	4	6	4
4 Men, @ $2·25 each	9·00	1	17	0
24 Men, @ $2·00 each	48·00	9	17	3
18 Teamsters @ $1·80 each	32·40	6	13	2
65 Men, @ $1·50 each	97·50	20	0	9
8 Waterboys, @ $1·25 each	10·00	2	1	1
Feeding 40 mules	15·00	3	1	7
Fuel and wages on train	24·00	4	18	7
Ten per cent. for wear and tear	26·60	5	9	4
Total cost per diem	$292·50	= £60	2	0

Cost per diem.

The rails being always 30ft. in length, each length is termed a panel, and one man, who is called a "panel spacer," carries a 30ft. pole and a pick, his duty being to keep far enough ahead as a road maker. Pannel spacer.

The two unloaders in the rail gang assist in loading the rail trolly, and while these rails are being laid they throw off another trolly load, consisting of thirty rails. Unloaders.

The front gang of spikers (a pair to each 30ft. rail) spike three sleepers in each "panel," always the joint and the sixth and eleventh sleepers, omitting four sleepers each time. Five other men in this gang distribute the fishplates, nuts and bolts, and fish the joints. Front gang.

The sleeper loaders unload the sleepers from the train as fast as required. Sleeper loaders.

Should the back spikers get behind they are assisted by the front spikers. Back spikers.

The sixteen teams carry fourteen loads of twelve sleepers each per day—making 2,688 sleepers. Teams.

The sleepers and rails are delivered at the last side track—these sidings being about eight miles apart. The train consists of ten flat cars of sleepers in the rear and three cars of rails in front of the locomotive, or just sufficient material for half a mile of railway. It starts from the camp at 6 o'clock a.m., dropping the back fillers, liners, and back spikers, where they stopped work on the previous night; and the ten cars of sleepers are left far enough back to give sufficient room to allow the rail car to get at the unloaded rails. The ten cars of sleepers are moved up as fast as the rails are laid, so as to make the haulage as short as possible, and only enough are unloaded at each time to keep the teams busy and prevent delay. Sidings for materials· Train. Mode of procedure.

At noon the train returns with the men to the depôt for dinner, and the empty cars are side tracked, and another train of ten cars of sleepers and three of rails are brought up to the depôt ready to take the men back after dinner. The sleeper cars are loaded with 135 sleepers each, or twenty cars to a mile, while the rail cars are loaded sixty rails each, or six cars to the mile. Only one train at a time is used for the work, and usually a 100-barrel water truck is added to it. The line is not surfaced by these gangs, but enough material is put on the road to keep the sleepers squared and spaced. As the front spikers spike the first joint and the sixth and eleventh sleeper in each rail, there are twelve sleepers left for the back spikers, the front pair of whom spike the third, fifth, eighth, tenth, thirteenth, and fifteenth sleepers, leaving as many more for the other pair.

The force as organised above lays one and a quarter miles of rails per day, but cannot keep up the back work. The gang therefore cannot lay much more than one mile complete per day. One mile of rails laid per day.

Mr. Johnson states he is laying 50lbs. steel rails, square and supported joints, no nutlocks, sleepers all full spiked—fifteen to each 30ft. rail—spaced 2ft. centres square to the track, laid to a line on the right hand side at the above rate.

Ballast Unloader.

When on the Union Pacific Railway I saw a contrivance for unloading ballast or earth used in making a railway. A single rail is laid down the centre of a train of flat trucks, upon which a plough or mould-board runs from end to end of the train, the plough being carried on the last truck. As soon as the train arrives at the place where the ballast is required, the truck wheels are scotched, the locomotive unhooked, and a wire rope is attached from the rear end of the tender to the front of the plough, and as the locomotive advances the plough clears off the whole of the ballast or earth loaded on every truck, and it falls on either or both sides of the line, as may be necessary. Where long lengths of line have to be ballasted and labor is scarce, this device answers perfectly and effects a great saving in time and money. It is known as "Merrill's Ballast Unloader," and can be obtained from the Railway Supply Company, Toledo, Ohio. Ballast Unloader. Merrill's ballast unloader.

Steam Shovels and Derricks.

Steam excavators are much used in the States for railway construction, and in average ground are very economical in working. They are all on the same principle, *i.e.*, a truck carrying an adjustable derrick and shovel or bucket attached to a fixed arm, and by means of gearing the shovel or digger is lowered, and in being raised excavates the material, which is swung round and deposited on the trucks alongside. They are each capable of excavating four cubic yards of gravel per minute, and the machinery is strong enough to lift eight tons with the derrick. The excavators are self-propelling, and weigh about forty tons each. Steam excavator. Excavate from 1,000 to 2,000 yards per day.

Mileage

Mileage of railways in United States and Canada.

Mileage of Railways in Operation in United States and Canada up to November, 1883.

Gauge of Line. Ft.	in.	Length of Line. Miles.
2	0	34
3	0	7,622
3	6	514
4	0	218
4	3	74
4	8½	95,328*
4	9	10,168
4	9¼	178
4	9½	57
5	0	13,628
5	6	76
Total		127,897 miles.

* Of this distance there are—405 miles of mixed gauge (4·8½ and 3·0).
26 " " (4·8½ and 4·3).
1,140 " " (4·8½ and 6·0).

Abstract of Railway Reports for New York State for Year ending September 30th, 1882.

I have extracted the following interesting information from the annual report of the New York State Engineer and Surveyor on the railroads of New York State, as laid before the Legislature April 8th, 1882.

In the State of New York there are 324 corporations organised under the laws of the State, and required to make annual reports to the State Engineer. Of this number 260 have complied, and the following abstract is compiled therefrom :—

Proportional capital, stock, and indebtedness for New York State, $703,996,779·94 = £146,665,995.

Mileage of Roads in Operation.

Miles of main line	7,369½
Miles of branches	2,689
Total miles in operation	10,058½
Total miles of road in New York State	6,641
Total miles of single track in the State	10,449½

Equipment.

Locomotives for passenger service	883
" freight service	1,752
" switching service	631
" mixed service	71
" leased but not owned	204
Total locomotives in use	3,541
being one engine for every 2·84 miles of road in operation.	
Cars—First class passenger	2,297
Average one car for each 4·18 miles of road.	
Cars—Second class and emigrant	552
Average one car for each 18·22 miles of road.	
Cars—Baggage, mail, and express	876
Average one car for each 11·48 miles of road.	
Cars—Freight of all kinds owned by corporations	114,494
Cars—Freight leased but not owned	25,746
Total freight cars in use in the State	140,240
Or an average of 13·94 for each mile of road.	

Cost of Roads and Equipment.

Proportional cost of roads for the State of New York	$464,105,946 = £96,688,739
Proportional cost of equipment	$63,073,727 = £13,140,359

Receipts and Expenditure during the Year ending September, 1882.

Total Receipts from all sources	$118,766,939 = £24,743,112
Proportional receipts for the State of New York	$78,421,989 = £16,337,914
Total Expenditure	$117,462,593 = £24,471,373
Proportional expenditure for State of New York	$73,233,357 = £15,256,949

Transportation of Passengers and Freight during the Year ending September, 1882.

Miles run by passenger trains	27,715,904
Total number of passengers transported	66,691,562
Number transported one mile	1,677,388,206
Average number of miles travelled per passenger	25
" passengers per train	60
Average amount received per passenger per mile	2·02 cents = 1·01d.
Average cost of transportation per passenger per mile	1·40 cents = 0·7d.
Miles run by freight trains	50,323,001
Total number of tons transported	71,171,516
" " " one mile	8,852,782,515
Average tons of freight per train	176
Average miles travelled for each ton	124
Average amount received per ton per mile	0·8168 cents = 0·4084d.
Average cost of transportation per ton per mile	0·6166 cents = 0·3083d.
" of maintaining the road and estate per mile	$1,893 = £394 7 6
" for repairs of machinery and cars per mile	$1,367 = £284 15 10
" for operating road per mile	$4,495 = £936 9 2
" for transportation expenses per mile	$7,756 = £1,615 16 8
Average number of persons employed for each mile of road	8
" " " on the surface steam railways of the State during the year ending September 30th, 1882	80,258

Elevated Steam Railways.

The only railways of this class in New York State are the "New York Elevated" and the "Metropolitan Elevated," both of which are leased to and operated by the "Manhattan Railway Company":—

Capital, Stock, and Indebtedness.

Total capital, stock, and indebtedness	$48,965,639 = £10,201,174

Miles of Road in Operation.

Miles of main line	31¾
Miles of branches	¾
Total miles in operation	32½
Total miles of track	79½

Equipment.

Locomotive engines	219
Cars—First class passenger	610
Cars for service	20

Cost of Road Equipment.

Total cost of road equipment	$34,882,790 = £7,267,247

Receipts and Expenditure.

Total Receipts	$5,973,633 = £1,244,506
Total Expenditure	$5,657,501 = £1,178,646
Miles run by trains	5,917,051
Number of passengers transported	86,361,029
Average amount received per passenger	6·86 cents. = 3·43d.
Average cost of transportation per passenger	4·25 cents. = 2·125d.

Miscellaneous.

Percentage of total expenses to gross earnings	61·10
Average cost per mile for maintaining the road and real estate	$10,223 = £2,129
" " repairs to machinery and cars	$15,936 = £3,320
" " operating road	$87,026 = £18,130
" " transportation	$113,186 = £23,580
Average number of persons employed to each mile of road	116
" " " on the Elevated Railways of the State of New York	3,766

Light Lines of Railway.

Before entering upon this subject, it is desirable that I should draw attention to the results that have been attained in constructing light lines of railway in the colony of South Australia.

The first attempt to construct light locomotive railways was made in 1867, when, together with two other lines of railway, the line between Roseworthy and the Burra (75 miles long) was commenced. This

Gauge. Formation grades and curves. Bridges and culverts. Rails. Sleepers.

line is on the 5ft. 3in. gauge, and as it traversed easy and undulating country was made with a formation width of 16ft. 6in. in cuttings, and 18ft. in embankments, with a ruling gradient of 1 in 100, and minimum curves of 20 chains radius. The walls of the culverts and bridges were built of rubble masonry, with hammer-squared beds and joints, and with timber girders for the former, and wrought-iron girders for the latter. There was one large iron-girder bridge built over the river Light in two spans of 150ft. each, and a central pier of cast iron 80ft. in height. The permanent way was laid with 40lbs. wrought iron rails (Vignoles section), spiked to hard wood sawn sleepers, 9ft. long by 9in. wide by 4½in. thick, spaced 2ft. 9in. apart, centre to centre. The rails were jointed over the sleepers and fished in the ordinary manner, except on curves, where Adams' bracket fishplates were used.

Ballast.

The ballast consisted principally of limestone, broken to 2½in. gauge, and spread on the formation to a depth of 8in. under the centre of the sleeper, and 9in. under each rail.

Stations. Workshops.

The stations were of an inexpensive character, about six to eight miles apart, and were provided with goods-sheds, offices, and residences for the station-masters, as well as cranes, platforms, weighbridges, water supply where required, and all other conveniences, including a telegraph, as well as a running-shed and workshops at Riverton.

Engines.

The engines were light, weighing only 26 tons gross, having four wheels coupled and a Bissel leading bogie—there being no greater weight on any wheel than 3⅛ tons.

Trucks.

The trucks were also built of a light pattern, weighing 4 tons 4cwts., and with journals capable of carrying 7 tons safely, although 6 tons was the practical limit of load.

Speed fixed, but soon exceeded.

The speed of passenger and goods trains (mixed) was fixed at twenty miles an hour, but this rate was soon exceeded, and speeds of thirty to thirty-five miles an hour (passenger trains only), were frequently attained owing to the constant pressure of the public upon the Government to increase the rate of travelling.

Report to Government.

As soon as the first section (twenty-four miles) was opened in 1868, I reported to the Government on this question in the following words:—"It must be distinctly borne in mind that the success or otherwise of the "economical working of this line will depend upon two circumstances—the weight imposed by the rolling-"stock upon the rails, and the speed of the trains. The weight on any wheel of the engines should not "exceed 3⅛ tons, and the speed should be limited to ten miles an hour for goods and from fifteen to twenty "miles an hour for passengers."

Heavier engines required.

The exigencies of the traffic, however, became so great that, before the line was finished to the Burra (in August, 1869,) it was necessary to put on heavier engines, having a weight of 4½ tons on the driving wheels, to work the trains. This speedily caused the light rails to laminate, and in some cases to fracture at the joints, until it became necessary, in 1877, to strengthen the bridge girders, and to commence relaying the line with 60lbs. steel rails—a work which, at the present date (1883), is not completed.

Relaying with 60lbs. rails.

Cost per mile.

The cost of construction of this railway, including sufficient rolling-stock to open the line for traffic, was £5,247 per mile complete.

The experience gained in this colony by the construction of this railway shows that a 40lb. rail is quite equal to a limited traffic with speeds not extending thirty miles an hour for passengers, and fifteen miles an hour for goods trains, on a gauge of 5ft. 3in., provided the road has good ballast, a sufficient number of good sleepers, light rolling-stock, and is well maintained; but I am convinced that the additional cost of increasing the weight of the rails to 60lbs. to the yard would have resulted in greater economy, because the cost of maintenance would have been materially reduced.

Another line was also constructed from Kapunda to Morgan, on the Murray river; but this railway runs over the Eudunda ranges, and has a ruling gradient of 1 in 60, and a minimum radius of 10 chains for curves. It is fifty-six miles in length, is laid with steel rails 41lbs. per yard, and cost £5,639 per mile, including sufficient rolling-stock to open the line for traffic.

An extension of the Burra line to Hallett, passing through easy country, and laid with 41lbs. steel rails, cost £5,000 per mile, including sufficient rolling-stock to open the line for traffic.

The above prices are low, when the high price of labor and materials and the durable nature of the works executed are taken into consideration; and it is extremely doubtful whether it is possible to construct and completely equip a light railway of the 5ft. 3in. gauge over average country in this colony for less than £5,500 per mile.

Cost of the Construction of Railways in South Australia and Victoria compared.

I append a statement which I have had prepared showing the system, length, gauge, cost per mile, &c., of all the railways that have been constructed and opened for traffic in South Australia, also a similar statement showing the system, length, gauge, cost per mile, &c., of all the railways that have been constructed in Victoria, including the "Light Lines" authorised in Mr. Patterson's Railway Scheme—Act No. 682 of 1880.

By comparing the average cost of each system, it will be found that the railways in South Australia will stand the test and show a better result, when the nature of the accommodation afforded at stations, in the shape of sidings, &c., and the enduring quality of the materials and workmanship used in the construction of the lines are taken into consideration; while, on the other hand, I note that, after a recent inspection of some of the "Light Lines" in Victoria, it is intended to expend a considerable sum of money in strengthening them and rendering them fit to carry the present traffic.

It

It must be borne in mind that the cost of our railways includes every item requisite for opening and working the lines in a complete state for the existing traffic; and comprises all station appliances, such as cranes, weighbridges, water-tanks and columns, furniture and office fittings, telegraph, block signals, and, in some instances, interlocking gear; and it invariably includes the provision of rolling-stock, running-sheds, shop machinery, and maintenance of way and works and buildings for one year after the line is opened for public traffic.

Items included in cost of South Australian Railways.

It would be an easy matter to construct railways in this colony through ordinary country for a less amount than the average cost given in the tables below; but this could only be done at a sacrifice of either the strength of the permanent way, the quality of the works, or the quantity of the equipment provided; and if such a system were adopted, additional funds must necessarily be expended, within the first year or so after the line is opened for traffic, in providing the accommodation required to work it, and in maintaining a light and weak permanent way and works.

SOUTH AUSTRALIAN RAILWAYS.

STATEMENT showing the COST of CONSTRUCTION of EACH LINE, the TOTAL LENGTH of which was OPEN for TRAFFIC on June 30th, 1883, with Average Cost per Mile, Highest and Lowest Levels, Steepest Gradients, &c.

		Length of Lines Open for Traffic.			Height of Rail-level above Low Watermark, Port Adelaide.		Steepest Gradient.	Cost, exclusive of Rolling-stock.	
		Double.	Single.	Total.	Highest.	Lowest.		Total.	Average per Mile.
	PORT AND NORTH LINES.	Miles.	Miles.	Miles.	Feet.	Feet.	Feet.	£	£
5ft. 3in. gauge.	Adelaide and Port Adelaide	7½	—	7½	100	14	1 in 86	165,561	22,075
	Port Adelaide and Semaphore	—	1¾	1¾	22	14	1 " 48	†81,099	46,342
	Adelaide and Kapunda	1½	49½	50½	745	14	1 " 62	610,968	12,098
	Dry Creek and Port Adelaide	—	4¼	4¼	14	12	1 " 287	29,107	6,128
	Roseworthy and Tarlee	—	24	24	624	257	1 " 80	159,665	6,611
	Tarlee and Burra	—	46½	46½	1,613	624	1 " 90	317,078	6,819
	Burra and Hallett	—	18½	18½	1,970	1,551	1 " 94	122,838	6,640
	Hallett and Terowie	—	20	20	1,970	1,632	1 " 85	147,841	7,392
	Kapunda and North-West Bend	—	56¾	56¾	1,528	41	1 " 60	397,061	6,997
	Gawler Tramway	—	1¼	1¼	184	164	1 " 42	8,426	6,741
	Total	8¾	222¾	231½	—	—	—	2,038,644	Average: * 8,806
	HAMLEY, WAKEFIELD, WALLAROO, AND SNOWTOWN.								
	Port Wakefield and Hoyleton	—	28	28	636	17	1 in 77	86,984	3,107
	Hoyleton and Blyth	—	14	14	782	602	1 " 87	74,047	5,289
	Port Wakefield and Kadina	—	34¾	34¾	484	16	1 " 76	178,551	5,139
	Kadina and Barunga Gap	—	26¼	26¼	786	116	1 " 60	73,263	2,791
	Barunga Gap and Snowtown	—	6¼	6¼	786	347	1 " 50	32,664	5,226
	Hamley Bridge and Balaklava	—	22	22	453	228	1 " 55	90,323	4,106
	Kadina, Wallaroo, and Moonta	—	20	20	141	12	1 " 80	91,140	4,557
	Moonta and Moonta Bay								
	Kadina and Wallaroo	—	6	6	141	28	1 " 80	24,302	4,050
	Total	—	157¼	157¼	—	—	—	651,274	Average: 4,142
3ft. 6in. gauge.	PORT PIRIE, TEROWIE, AND QUORN.								
	Port Pirie and Gladstone	—	32½	32½	738	14	1 in 96	191,176	5,882
	Gladstone and Jamestown	—	19½	19½	1,493	738	1 " 95	77,231	4,012
	Terowie and Pichi Richi	—	116½	116½	2,012	770	1 " 69	442,150	3,795
	Total	—	168¼	168¼	—	—	—	710,557	Average: 4,223
	GREAT NORTHERN LINE.								
	Port Augusta and Government Gums	—	198¼	198¼	1,340	18	1 in 60	898,436	4,532
	SOUTH-EASTERN SYSTEM.								
	Kingston and Naracoorte	—	52½	52½	184	5	1 in 100	181,830	3,463
	Naracoorte and Tatiara	—	44	44	370	184	1 " 100	140,067	3,183
	Rivoli Bay and Mount Gambier	—	51¼	51¼	177	3	1 " 100	174,378	3,402
	Total	—	147¾	147¾	—	—	—	496,275	Average: 3,358
	Grand Totals	8¾	894¼	903	—	—	—	4,795,186	5,310

* This includes the whole of the Wharf lines at Port Adelaide (about seven miles), also the whole of the Locomotive and Carriage Workshop lines (about 4¼ miles) at Adelaide and Islington, which serve for the whole of the South Australian Railways.

† This includes the "Jervois" swing bridge, which is both a railway and road bridge.

MEMO.—The whole of the provision for additional requirements for each system, including the additional line of rails between Adelaide and Port Adelaide, and Adelaide and North Adelaide, has been divided *pro rata*, according to the mileage of each line of that system.

VICTORIAN RAILWAYS.

STATEMENT showing the COST of CONSTRUCTION of EACH LINE, the TOTAL LENGTH of which was OPEN for TRAFFIC on December 31st, 1882, with Average Cost per Mile, Highest and Lowest Levels, Steepest Gradients, &c.

	Length of Lines Open for Traffic.			Height of Rail-level above Low Watermark, Hobson's Bay.		Steepest Gradient.	Cost, exclusive of Rolling-stock.	
	Double.	Single.	Total.	Highest.	Lowest.		Total.	Average per Mile.
NORTHERN SYSTEM.	Miles.	Miles.	Miles.	Feet.	Feet.	Feet.	£	£
Main Line—Melbourne to Sandhurst (including Melbourne terminus)	100¼	—	100¼	1,902	17	1 in 50	5,241,270	52,023
Echuca Line—Sandhurst to Echuca Wharf	—	55¼	55¼	753	320	1 " 90	614,965	11,131
Lancefield Line	—	14¼	14¼	1,675	1,072	1 " 40	760,865	4,198
Carlsruhe and Daylesford Line	—	22¾	22¾	2,469	1,791	1 " 50	154,846	6,806
Castlemaine and Dunolly Line	—	47½	47½	949	580	1 " 40	289,879	6,103
Dunolly and St. Arnaud Line	—	33	33	945	611	1 " 50	157,482	4,772
St. Arnaud and Donald Line	—	23¾	23¾	868	374	1 " 50	83,673	3,523
Ballarat and Maryborongh Line	—	42½	42½	1,525	732	1 " 40	260,512	6,130
Ballarat Racecourse Line	—	2	2	1,508	1,466	1 " 50	6,921	3,461
Maryborough and Avoca Line	—	15	15	883	721	1 " 40	60,768	4,051
Sandhurst and Inglewood Line	—	30	30	778	442	1 " 43	151,628	5,054
Total	100¼	286¼	387	—	—	—	7,082,809	Average: 18,302
WESTERN SYSTEM.								
Williamstown Line—Footscray Junction to Williamstown, including Piers and Breakwater	6	—	6	66	12	1 in 100	418,462	69,744
Geelong Line—Newport to Geelong (including line to Wharf)	1¾	37¼	39	113	12	1 " 81 & wharf line 1 " 50	1,059,912	28,454
Ballarat Line—West Geelong to Ballarat	53½	—	53½	1,725	47	1 " 52	1,732,385	32,381
Geelong and Queenscliffe Line—Queenscliffe Junction to Queenscliffe	—	20¾	20¾	263	10	1 " 50	106,870	5,150
Geelong and Colac Line (including Racecourse Branch)	—	52½	52½	465	17	1 " 50	343,039	6,534
Warrenheip and Gordons Line	—	13	13	1,940	1,707	1 " 50	82,439	6,341
Ballarat and Ararat Line	—	57	57	1,517	960	1 " 44	317,635	5,573
Ararat and Stawell Line	—	18¾	18¾	1,086	759	1 " 50	115,695	6,170
Stawell and Horsham Line	—	53½	53½	759	423	1 " 50	236,987	4,430
Horsham and Dimboola Line	—	21¼	21¼	477	361	1 " 50	58,432	2,752
Ararat and Hamilton Line	—	66½	66½	1,028	572	1 " 50	312,031	4,692
Hamilton and Portland Line (including line to Portland Wharf)	—	54	54	605	11	1 " 50 & wharf line 1 " 40	268,477	4,972
Total	61¼	394½	455¾	—	—	—	5,052,414	Average: 11,086
NORTH-EASTERN SYSTEM.								
Essendon Junction to Essendon and Racecourse Branch	5	—	5	148	14	1 in 67	94,354	18,871
North-Eastern Line—Essendon to Wodonga	—	182	182	1,148	105	1 " 50	1,601,757	8,801
Mangalore and Shepparton Line	—	45	45	476	372	1 " 100	231,112	5,136
Toolamba and Tatura Line	—	7	7	385	371	1 " 108	26,633	3,805
Wangaratta and Beechworth Line	—	23	23	1,831	502	1 " 30	155,969	6,781
Springs and Wahgunyah Line	—	14	14	622	454	1 " 50	66,428	4,745
Shepparton and Numurkah Line	—	20½	20½	376	348	1 " 206	61,141	2,495
Total	5	291½	296½	—	—	—	2,237,394	Average: 7,546
EASTERN SYSTEM.								
Spencer and Flinders streets Junction	—	¾	¾	17	6	1 in 23	6,099	8,132
South Yarra and Oakleigh Line	3¾	3	6¾	184	22	1 " 50	197,733	29,294
Gippsland Line—Oakleigh to Sale	—	118½	118½	513	32	1 " 50	763,793	6,459
Hawthorn and Lilydale Line	—	20¼	20¼	484	41	1 " 40	142,405	7,032
Caulfield and Frankston Line	—	20	20	167	10	1 " 50	99,522	4,976
Hobson's Bay Lines (including the Sandridge Pier)	16½	—	16½	53	10	1 " 100	1,338,753	81,137
Total	20¼	162¼	182½	—	—	—	2,548,305	Averages: 13,963
Grand Total	187¼	1,134½	1,321¾	—	—	—	16,920,922	12,802

Gauge of lines, 5ft. 3in. in all cases.

Items Nos. 2 and 3.—WORKING WITH MIXED GAUGES SUCH AS THE GREAT WESTERN.

FRENCH RAILWAYS.

French Railways.

The only cases of this kind of which I could gain any information in France were those in which it was necessary to transfer coals from narrow (metre) gauge to the standard (4ft. 8½in.); and this was done by the engine pushing the trucks to the end of a platform, one end of the wagon then being raised by hydraulic power sufficiently to allow the coals to slide into the wagons on the lower level, thus preventing to a great extent the breakage of the coal.

Lifting bodies abandoned.

The Chief Engineer of the narrow-gauge railways, Monsieur Renault, informed me that the plan of lifting the bodies of loaded vehicles, and transferring them from one gauge to another, had been tried and was abandoned, the mode now adopted being to move by hand all goods across platforms constructed for the purpose. (See Plate No. 23.)

Plate No. 23.

ENGLISH RAILWAYS.

English Railways.

In England, on the Great Western from London to Exeter, the broad gauge has not been entirely dispensed with; trains are still running on the 7ft. gauge; and the express trains run over the standard gauge system of this railway at an average speed of forty-five miles an hour, including stoppages; while the speed of the "Flying Dutchman" is fifty-nine miles an hour.

Trains also run from Paddington station on the mixed gauge, *i.e.*, 4ft. 8½in. and 7ft., to Gloucester; and on several of the branch lines of the Great Western the broad has been replaced by the standard gauge of 4ft. 8½in.

Mr. Rendel, in writing to the Chief Engineer of narrow-gauge railways in Norway on the subject of break of gauge, says:—"The fancied evils of break of gauge make many enemies amongst ignorant or "prejudiced people for narrow-gauge lines. It is all nonsense; the mischief is measured on our long "distances (India) by the cost of transfer from one set of wagons to another, which is done by contract at "about 1½d. per ton, equal to the cost of transport for two and a half to three miles." But as a set off against Mr. Rendel's statement it will of course be remembered that labor in India is very cheap.

AMERICAN RAILWAYS.

American Railways.

Bell's Mills.

There is a contrivance in constant use at Bell's Gap, near Altoona, Pennsylvania, whereby the bodies of coal cars are transferred from the 3ft. 6in. to the standard 4ft. 8½in., and *vice versa*, by means of a pit with an incline in it at each end laid with the two gauges. On the top of the pit are laid two rails of a wide gauge, which carry the wheels of the bogies supporting the body of the car, which is pushed along the pit, and in passing along the one set of bogies fall away from the centre-pins, and the other set being ready at the other end of the pit, are attached to the centre-pins as the car leaves the pit, so that by this means the bogies only are changed in a very short time—under five minutes.* At St. Louis the car is brought to a changing siding, where it is lifted by screws, and the bogies are exchanged without moving the loaded carbody. It has, however, been proposed to substitute hydraulic power for screws. (See Diagram. Plate No. 23D.)

St. Louis. See Diagram. **Plate No. 23D.**

In the course of my travels I could not hear of any successful plan whereby the ordinary truck bodies could be lifted from their frames, neither did I hear of any perfect plan whereby the wheels could be shifted on their axles. Although there are several patents issued in England and America for this purpose, the principle is not adopted in practical working.

Items Nos. 4, 5, and 6.—LIGHT LOCOMOTIVES FOR SUCH LINES AS THE STRATHALBYN AND MILANG RAILWAY (without alteration).

I made inquiries on this subject at several places, including Messrs. Beyer, Peacock & Co., and Kitson & Co., and I append lithographs of the engines which are recommended as being suitable for such a line as the Strathalbyn Railway.

Beyer, Peacock & Co. **Plate No. 24.**

The engines of Beyer, Peacock & Co. (Plate No. 24) have the following dimensions:—

Tank engine, drawing No. 34,903 (5ft. 3in. gauge), has a saddle-tank on the boiler holding 200 gallons of water. The inside cylinders are 7½in. x 14in. stroke; wheels (four), 3ft. 6in. in diameter, coupled; boiler, 7ft. long x 2ft. 7½in. in diameter, with seventy-five brass tubes 1⅝in. in diameter outside; copper firebox, 2ft. 4in. long x 2ft. 3in. wide x 3ft. 2in. high. Heating surface:—Tubes, 231 sq. ft.; firebox, 27 sq. ft.; total, 258 sq. ft. Area of firegrate, 5¼ sq. ft.; traction-power equal to 18¾ sq. in. of piston area; weight in working order, 10½ to 11 tons.

Tank

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* The "Ramsey" carbody Transfer, constructed by the Bell's Gap Railroad Company in the spring of 1881, has been in successful operation since that period, transferring daily an average of 50 bodies by hand. The Transfer is on a grade of 1 in 100, worked by gravity, and the maximum capacity is 100 tons daily, costing per ton for transferring five cents., or 2½d. per ton. Cost of the construction of the Transfer, excluding sidings, £300. (Extract from letter from Superintendent at Bell's Gap, May 22nd, 1883.)

Tank engine, drawing No. 34,904 (5ft. 3in. gauge), has a tank under the boiler holding 200 gallons of water; cylinders (outside), 7½in. x 14in. stroke; wheels (four), 3ft. 6in. in diameter, coupled; boiler, 7ft. 5in. long x 2ft. 7½in. in diameter, with seventy-five brass tubes 1⅝in. in diameter outside; firebox of copper, 2ft. 4in. long x 2ft. 3in. wide x 3ft. 2in. high. Heating surface:—Tubes, 246·75 sq. ft.; firebox, 27 sq. ft.; total, 273·75 sq. ft. Area of firegrate, 5·25 sq. ft.; traction-power equal to 18¾ sq. in. of piston area; weight in working order, 10½ to 11 tons.

Each engine provided with two injectors, steam and hand brake acting upon all the wheels. Boilers to be Yorkshire or other best ironplate; fireboxes of best selected copper; tubes of best drawn brass; wheels of wrought iron, fitted with Krupp's or Vicker's steel tires and axles.

Complete set of tools for each engine is also provided, and the price for four of either type would be £1,125 each. Cost.

Either of these engines would haul, on a grade of 1 in 60, three tram cars fully loaded, weighing five tons each, or twenty-six tons of goods. They would run freely with passengers from fifteen to twenty miles per hour. Duty and speed.

Messrs. Kitson & Co., of Leeds, also forwarded a diagram of an engine (see Plate No. 25, in appendix) suitable for working the Strathalbyn or Port Broughton lines. The engine has four wheels, extreme centres 5ft. Locomotive type of boiler, 2ft. 5in. in diameter, ⅜in. Yorkshire plates; working pressure, 160lbs.; firebox (best copper), $\frac{7}{16}$in. thick; tube plates, ⅜in. to $\frac{7}{16}$in. thick; stays of Yorkshire iron, carried direct to firebox shell; tubes (seamless brass), 1½in. diameter outside. Cylinders (outside), 7½in. diameter x 12in. stroke; valve chests on top. Pistons (cast iron), with steel rods; valves (Allan type), double-ported; link motion (Kitson's patent), no eccentrics; wheels (cast iron), with specially hard crucible steel tires, 2in. thick; axles (Yorkshire iron), with case-hardened journals; axleboxes (cast iron), with spring lubricating pads below; brushes; phosphor bronze. Hornblocks, horseshoe form, with removable liner pieces; lock-up safety valves; tank to contain 152 gallons of water. Two trunk pumps; all working parts case hardened. Kitson & Co. Plate No. 25.

Weight, 7 tons; gauge, 5t. 3in.; maximum speed, twenty miles per hour; average, twelve to fifteen miles per hour; water carried, equal to a ten-mile run; load, 16 tons, up grade of 1 in 60, exclusive of engine; price, f.o.b. Liverpool, £780. Speed and duty. Cost.

The Messrs. Kitson also make very good engines for tramway purposes, and I had an opportunity, when in Bradford, Yorkshire, of riding on them and seeing their performance. They make three types specially for this purpose.

No. 1 has four wheels coupled, with cylinders 7½in. x 12in.; wheels, 2ft. 4½in. diameter; with water-tank to contain 80 gallons, and a condenser for waste steam; with Board of Trade requirements; weighing empty, 6½ tons; when loaded 7 tons; and delivered f.o.r. in Leeds, £780 each. Steam motors.

No. 2 has four wheels coupled, with cylinders 8in. x 12in.; wheels, 2ft. 4½in. diameter; with water-tank to contain 80 gallons; a condenser, an additional tank condenser, and Board of Trade requirements; weighing empty, 6 tons 8cwt.; when loaded, 7 tons 12cwt.; delivered f.o.r. in Leeds, £810 each.

Nos. 1 and 2 are more specially suitable for street tramway purposes.

No. 3 has six wheels coupled, with cylinders 11½in. x 15in.; wheels, 2ft. 6in. diameter, fitted with water-tank to contain 250 gallons; an atmospheric condenser, and Board of Trade requirements; weighing empty, 10¾ tons; and when loaded, 12½ tons; delivered f.o.r., Leeds, £1,245 each.

No. 3 would be suited for the light traffic of the Strathalbyn Railway.

Messrs. Kitson & Co. also make "Rowan's" patent steam cars, by which system the paying-load of vehicles is used for the purposes of adhesion; and, as the engine is carried on a swivelling bogie-carriage, it is enabled to traverse sharp curves with facility. The engine can be readily separated from the car, and another engine attached when required. Rowan's Motors and steam cars.

It is claimed for this system that the combined car, with two tons less deadweight than the separate engine and car, has the same adhesive power, and can ascend a grade of 1 in 15 with a load which a separate engine would fail to draw up 1 in 30.

The engine is so separated from the passenger portion of the car, that absolutely no heat is felt from the engine by the passengers.

The classes chiefly made on this system are as under:—

No. 1 (R. 16)—Eighty to 120 passengers; baggage and postal compartment; fixed wheel-base, 8ft.; maximum weight per wheel when loaded, 3½ tons; speed, nineteen to thirty miles per hour. Duty and speed.

No. 2 (R. 12)—Forty to sixty passengers; baggage and parcels express and postal compartment; fixed wheel-base, 6ft.; maximum wheel-pressure, loaded, 2¾ tons; speed, twelve to twenty miles per hour. N.B.—Suitable for light lines with grades not over 1 in 25, and curves not less than three chains radius. Duty and speed.

No. 3 (R. 10)—Thirty to forty passengers; fixed wheel-base, 5ft.; maximum wheel-pressure, loaded, 1½ ton; speed, six to thirteen miles per hour; weight of car and engine, empty, 6½ tons. N.B.—Suitable for tramways on roads with curves of 50ft. radius or grades of 1 in 18. Duty and speed.

The cost of these combined cars would be as follows, No. 1 (R. 16), £1,500, f.o.b., London. No. 2 (R. 12), £1,430, f.o.b., London; with spare engine, £2,180, f.o.b., London. No. 3 (R. 10), £1,030, f.o.b., London; with spare engine, £1,780, f.o.b., London. The

team car No. 3. The steam car (R. 10), No. 3, would be quite suitable for working a line similar to that at Port Broughton.

The No. 3 class (R. 10) is of the following dimensions:—

Length over all	28ft.
Length of car body	22ft. 6in.
Outside width of car body	6ft. 3½in.
Weight, in working order	6 tons 7cwt.
Maximum wheel-pressure on rails, with full load	1 ton 7cwt.
Weight available for adhesion	5 tons 14cwt.
Number of seats for passengers	30
Traction force	1,100lbs.
Diameter of wheels	29½in.
Speed	up to 12½ miles per hour
Consumption of coke	about 5½lbs. per mile

Requires fresh water every two hours.

Item No. 7.—SHEEP AND CATTLE TRUCKS.—MODE OF LOADING AND DISCHARGING, WATERING, FEEDING, &c., ON LONG JOURNEYS, RACES, RAMPS, &c.

EUROPEAN RAILWAYS.

European Railways.

Ordinary system in use. London, Chatham, and Dover Railway.

Loading.

Feeding and watering.

Company feed and water if stock is in charge more than eight hours.

On the European and English railways the companies, as a rule, make no special provisions for feeding and watering cattle or sheep during the journey; but this traffic is dealt with at the ordinary cattle docks, where water is laid on, and the freighters make their own arrangements for feeding the stock in transit. The management and inspection of the cattle-pens at stations is under the direction of the Privy Council, who adopt stringent measures to ensure that the cleansing and watering are carried out. On the London, Chatham, and Dover Railway the sheep are loaded and unloaded by means of a wharf on the same level as the floor of the truck, the flap of the truck resting on the wharf, and forming the gangway for the passage to and fro. Watering the sheep is attended to by the company, when necessary, without charge. Feeding is also done by the company when required, at the rate of 3s. 6d. per truss for the fodder consumed. In case the sheep are in charge of the company for a longer period than eight hours, the company's officers consider the watering and feeding as a duty incumbent upon them.

AMERICAN RAILWAYS.

American Railways.

Bogie car stock.

On the principal lines in America the ordinary cattle and sheep cars are fitted with bogie trucks; but there are several stock car companies, among others, the Burton Stock Car Company, the Montgomery Palace Stock Car Company, and the Oehrl Improved Stock Car Company. I had an excellent opportunity of inspecting these cars during the week which I spent in Chicago at the exhibition of railway appliances.

Burton stock car.

Plate No. 21.

The Burton stock car is fully illustrated in the appendix to this report, and was designed to abolish the ordinary system, under which the animals suffered from close confinement, prolonged abstinence from food and water, and the great cruelty practised in transportation, resulting in bruises and sores, and in many cases death from trampling by their fellow beasts.

Advantages claimed.

It is claimed by the designers:—

1st.—That the cattle are fed and watered in the cars.

2nd.—That the cars and cattle can be readily kept clean.

3rd.—That the cost of construction does not exceed £50 more than an ordinary stock car of the same size.

4th.—That there is 36ft. of space without any obstruction, and that merchandise can be carried in the cars when they are not required for cattle.

5th.—That each animal can lie down and rise when it pleases, the cattle being secured independently of each other, and having for the purpose a space of 2ft. 10in. wide by 8ft. 7in. in length.

6th.—That as each car is mounted on suspension car trucks or bogies, with double elliptic springs and an airbrake, it can be run at passenger speed, and time in transit be thereby reduced.

7th.—That the cattle stand the lengthwise of the car, and are carried with greater comfort to themselves; and are afforded better protection to brace themselves against sudden motion and jerks of the train.

8th.—That it is unnecessary to enter the car to unload or feed the cattle, as this is all done from the top of the car, and one man can easily give proper attention to a train of twenty cars.

Shrinkage.

It has been proved over and over again that the loss by "shrinkage" has been reduced to 1·3 per cent. by this

this system of trucking cattle; whereas it not unfrequently happened that cattle sent from Chicago to New York in the ordinary cars lost as much as 60lbs. per head in shrinkage.

Act of Congress, 1878.

To such an extent was the system of cruelty and overcrowding practised in carrying cattle from the Far West to the eastern markets, that in 1878 Congress enacted a law prohibiting railway companies from overcrowding their cattle cars, or from confining the cattle, sheep, swine, or other animals, for a longer period than twenty-eight consecutive hours in the cars without unloading them for rest, water, and feed for a period of five consecutive hours; but an exception is made when animals are carried in cars in which they can and do have proper food, water, space, and opportunity to rest.

To give some idea of the traffic carried on in cattle alone in America, it may be mentioned that there are at the present time 35,000 cattle cars in use.

Cost.

The cost of "Burton" cars complete, but knocked down for shipment f.o.b. Boston is, for cattle £220, and for horses £230 each, to carry eighteen head of large cattle. The price of sheep or pig cars, double-decked, is £150 each. These prices are based on an order of not less than ten cars; and the expenses of freight, erection, and painting must be added.

Montgomery cattle palace car.

The Montgomery cattle palace car is on a similar principle to that of the Burton stock car, and was designed to effect the same objects.

Dimensions.

Each car is 38ft. 7in. long by 9ft. wide and 7ft. 6in. high. The four walls are made of slats, with two doors on diagonally opposite corners; the interior is divided into compartments by means of swinging gates made of slats and steel bands, with a rubber band running across the bottom near the floor, making it possible for the cattle to lie down and put their legs under the doors. Four head of cattle, and sometimes five, occupy one compartment, and full provision is made for watering and feeding as follows:—On the roof of each car are two oblong boxes in diagonally opposite corners, running parallel with the length of the car as far as the centre. These boxes contain the food for the cattle, and underneath are arranged revolving troughs of metal, placed at a convenient spot, which when not in use are secured so as to prevent dirt from entering. In the bottom of each box is a large iron valve operated by means of a lever fixed at the end of the car; a sufficient quantity of food having been placed in the boxes, the valves are opened by the levers and the food drops into the metal troughs.

Watering and feeding.

Feeding.

Watering.

Along the top of the interior of each car runs a 3in. waterpipe connected to the next cars by rubber hose, and from this main pipe smaller pipes run down the sides and connect with a perforated horizontal pipe running over the top of the troughs. To water the cattle the troughs are filled from the station water supply in a few seconds.

These cars are also hung as suspension trucks with elliptic springs, and fitted with airbrakes, giving an easy motion and enabling the cars to be run at passenger speed. Sand is sometimes used for the cattle to lie down upon.

Time in loading.

On the 26th May one trip was run from Chicago to Baltimore with sixteen loaded cars containing 288 head of cattle—the loading commenced at 2·30 p.m. and was finished at 3·17 p.m., occupying forty-seven minutes for the entire train.

The train left Chicago at 6·25 p.m., Columbus time, and ran—

Speed.

	131	miles at	21	miles an hour
thence	128	"	21	"
"	88	"	17¾	"
"	105	"	17½	"
"	95	"	21½	"
"	78¾	"	16	"
"	101	"	20¼	"
arrived Baltimore	114	"	26	"

or 856 miles in 43hrs. 50m., allowing for difference in time, from which must be deducted loss of time in watering engines, changing them, &c., equal to 6hrs. 24m., making the actual running time about 37hrs. 26m., or an average of 22·4 miles per hour.

Cattle carried.

Shrinkage.

The cattle carried were Texans, Colorados, Nebraskas, and Illinois, varying in weight from 1,790lbs. to 900lbs. each. It was found that four and five animals in a stall could lie down and rest at the same time, each having ample room; and for all the cattle bought and weighed on the day of shipment, numbering forty-four head, there was an average gain of 10lbs. per head; while those bought and weighed some days before shipment lost on an average 27½lbs. per head.

These cars are owned and worked by the Montgomery Palace Stock Car Company in a manner similar to the Pullman Car Company's passenger cars, the conductors of the company being in charge of the cars, and the shippers paying a royalty for their use.

Oehrl improved stock car.

Movable deck.

The Oehrl improved stock car is fitted with a deck, which is raised and lowered at pleasure, and is so arranged, that one man can in an instant change it from single to double-deck, or *vice versa*, this change being made in either end of the car, thus making it possible to carry three kinds of stock. By this contrivance cattle are prevented from rearing and injuring themselves. Arrangements are also fitted for feeding and watering, which, when not required, can be readily removed.

Item No. 8.—SHEEP-PROOF FENCING FOR RAILWAYS.

ENGLISH RAILWAYS.

English Railways.

The fencing adopted on English railways consists of stone walls (when stone is abundant), hurdles of timber, and hedges and ditches; wire is not frequently used.

AMERICAN RAILWAYS.

American Railways.

In America timber is used for fencing for railways, and in outlying districts fencing is dispensed with.

Item No. 9.—MANAGING LEVEL-CROSSINGS IN AMERICA, BOTH IN THICKLY AND SPARSELY POPULATED DISTRICTS.

AMERICAN RAILROADS.

American Railroads Plate No. 26.

Crossings in towns.

Vertically swinging gates.

Forming when open a complete signal.

Close across road and railway.

Level-crossings are very numerous on American railways, and in crossing the streets of cities and towns vertically swinging gate bars are worked simultaneously by the crossing-keeper (see Plate No. 26). They are termed "Winsor's patent railway safety gates," and are placed on each side of the railroad line at the crossing, and so connected that the crossing-keeper can open or close both gates from either of the four posts. The gates being perfectly balanced require very slight exertion to operate them. The standards carrying the gates are of iron, and the gates are of timber, framed and braced when required for wide spans, forming when open a complete signal—by day or night—to the engine-driver, and an assurance that the road is clear. When street-crossings are close together, one man can readily work two crossing-gates; and when it is required these gates are made in such a manner that when the street gate is open, two gates close across the railroad and prevent cattle from trespassing. Automatic bells are also used in connection with these gates, to warn those intending to pass that the gates are about to be closed. The gates made on this system are patented by the Railway Safety-gate Co., Central Fall, R.I., United States.

Cost.

Cattle guard.

The cost of four-post gate complete ready to erect would be about £100 per set, the weight of the castings being about 6,000lbs. To prevent sheep or cattle getting under the bar, movable slats, held equally distant by a longitudinal bottom strip, are attached, so that when the arm is raised the slats lie close to the arm.

Crossings in the country.

In sparsely peopled districts the level crossings have no gates, but are protected by two ditches, one on each side of the public road, in a similar manner to that adopted on the railways in this colony.

Crossing lines at grade.

It is the rule throughout the States for every train to pull up on approaching the crossing of another railway on the level, and the train then proceeds slowly over the crossing.

Item No. 10.—REFRESHMENTS ON RAILWAYS.

ENGLISH RAILWAYS.

English Railways.

Great Western.

The refreshment-rooms on the Great Western Railway are not managed by the company, but are leased or rented to outside persons. The practice is, whenever the refreshment-rooms at a station become vacant, to invite tenders for their occupation, and the directors select as a tenant the person who offers the most favorable terms, subject, of course, to proper inquiry being made and satisfactorily answered.

Terms of tenancy.

The tenant pays all rates, taxes, assessments and outgoings (except property tax), and at his expense supplies all furniture and fittings, except certain fixtures belonging to the company; he also lights and warms the rooms, and supplies, at his own cost, gas and water, and keeps the rooms open for all trains, and permits the rooms to be used as waiting-rooms by the railway passengers.

The company has the option of purchasing at a valuation, at the expiration of the tenancy, all fittings which the tenant has supplied.

The tenant is bound to supply the public using the rooms with proper and sufficient refreshments, of such description and quality as the directors may require, in accordance with a scheduled tariff of charges, and is

in

in all respects to obey and carry out the regulations, orders, and directions which he may receive from the directors through their general manager or divisional superintendent as to the management of the rooms.

The tenant is forbidden to supply intoxicating liquors to the servants of the company. In the event of fire the company is not responsible for loss or damage to goods or stock.

On the London and North-Western Railway the refreshment-rooms are, in the majority of cases, in the company's own hands, and are worked in conjunction with their hotels. London and North-Western.

On the Great Northern Railways the rooms are controlled by the company, who appoint a manager to conduct the business and take charge of the several stations. Great Northern.

AMERICAN RAILWAYS. American Railways.

At the chief depôts in America the refreshment-rooms are let by the company, while in some cases they are managed by a person appointed for the purpose by the company.

The railway companies frequently own the hotels in connection with the depôts, and at Monterey, in California, about 125 miles from San Francisco, the Southern Pacific Company have built a very fine hotel, called the Hotel del Monte Rey, which is situated on the coast in enclosed ground, 126 acres in extent, with 7,000 acres more reserved for other purposes. It is said to be without question the handsomest watering place hotel in America. It is 385ft. long by 115ft. wide, and has three stories, and is fitted with gas, and water supplied from artesian wells.

The journey (125 miles) from San Francisco to Monterey is accomplished in three and a half hours, and a very large traffic is maintained between the hotel and the city.

Item No. 11.—RAILWAY BRAKES: VACUUM AND PRESSURE.

EUROPEAN RAILWAYS. European Railways.

Although there are in use a variety of patented brakes, automatic and non-automatic, on the French lines, the Paris, Lyons, and Mediterranean and the Paris and Orleans Railways are using the Westinghouse automatic brake. French. Westinghouse automatic.

The Belgian State Railways and the Dutch Rhenish have also finally adopted the Westinghouse automatic brake. Belgian and Dutch Rhenish.

On the Bavarian States Railway the Heberlein brake is much used, and is of very simple construction. It is not continuous; but it can be readily applied to each of the vehicles in a train which is divided into sections. The brake is applied to the wheels by means of a pulley acted upon by a friction wheel on one of the axles of the guard's van. This friction-wheel, in revolving, winds a flat-linked chain, which is attached to a set of levers and rods running under the carriages, and operating the brakeblocks. A line runs along the carriage-roofs, and by pulling it a catch or detent is liberated, and the friction-pulley, which is attached to a weighted lever, falls into contact with the pulley on the axle, the result being that the chain is rapidly wound up, and the brakes applied. Heberlein brake.

ENGLISH RAILWAYS. English Railways.

The brakes which are principally used on the main lines in England are the Westinghouse and the Smith vacuum, with various modifications.

The London and North-Western Railway has used for many years the Clark & Webb chain brake, with its modifications; but this brake is now being superseded by a modification of Smith's vacuum brake, by Mr. Webb, which consists of a piston, having an angular recess cut in it, into which a flat rubber ring is slipped, making a tight joint with the inside of the cylinder. The local trains, however, retain the chain brake, in addition to the use of a steam brake on the locomotives. London and North-Western.

The Great Northern Railway has adopted the Smith non-automatic vacuum brake. Great Northern.

The Midland Railway uses a modification of Smith's automatic vacuum brake, by Mr. Clayton; which consists of a cast-iron cylinder and reservoir combined, with a loosely-fitting deep piston, having a round indiarubber ring, which rolls from one end to the other of the piston as the piston travels in the cylinder. The Midland Company also has forty-eight engines and eighty-five carriages fitted with the Westinghouse automatic brake. Midland.

The Lancashire and Yorkshire uses the Smith automatic vacuum brake. Lancashire and Yorkshire.

The London, Chatham, and Dover Railway uses the Westinghouse automatic pressure brake on the tidal trains and the Granville express, and Smith's non-automatic vacuum on the metropolitan trains from Victoria station to the Crystal Palace, having eighty engines and 386 carriages already fitted. London, Chatham, and Dover.

The Manchester, Sheffield, and Lincolnshire Railway uses the Smith non-automatic vacuum brake. Manchester, Sheffield, and Lincolnshire.

The London and South-Western Railway uses the Smith automatic vacuum, and has 133 engines and 532 carriages fitted. London & South-western.

The London, Brighton, and South Coast Railway has used the Westinghouse automatic brake since 1878, having 289 engines and 2,053 carriages now fitted, and running about 125,000 train miles weekly. London, Brighton, and South Coast.

The Metropolitan Railway (underground) uses Smith's vacuum brake. Metropolitan.

The Metropolitan District Railway (underground) uses the Westinghouse non-automatic brake, but previously used Wilkins and Clark's chain brake. Metropolitan District. The

Great Eastern. The Great Eastern Railway has adopted the Westinghouse automatic brake on the majority of its trains, and intends to apply it to all the stock, having already 210 engines and 1,737 carriages fitted.

Great Western. The Great Western Railway uses Deans's modification of Richard Sanders's automatic vacuum brake.

Diagrams are appended showing the cylinders, pistons, valves, &c., of the Smith's vacuum, Hardy's vacuum, Clayton's modification, Dean's improved Sanders brake, Vacuum Brake Company's automatic brake systems A and G, and non-automatic system C; also the Westinghouse automatic air-pressure brake.

Plates Nos. 27 and 28.

Smith's Vacuum Brake (Plates Nos. 27 and 28.)

Non-automatic. Smith's vacuum brake, as originally designed, was non-automatic, and consisted of an ejector on the locomotive by which the air was exhausted from a line of pipes with suitable couplings between the carriages, these pipes communicating by means of branch pipes to flexible cylinders, which collapse as soon as a vacuum is created within them.

Brake on. The covers of these collapsible cylinders or sacks were connected by suitable rods and levers to the brakeblocks, and, in the act of collapsing by the pressure of the external air, acted immediately upon the levers which worked the brakeblocks.

Brake off. To release the brake an airvalve is provided, which is placed on the locomotive or in the guard's van, and by admitting the air into the line of pipes and cylinders destroys the vacuum, and restores the latter to their normal condition.

Disadvantages. This brake is useless in case the hose pipes between the carriages or between the engine and carriages are severed, as the brakeblocks are thereby released, and in cases of accident from derailment this is most likely to occur at the very moment when the power of the brake is most required. It is also useless in working long and steep inclines, because it must be either "full on" or "off," and there are no means of graduating the pressure on the wheels of the vehicles. When once the brakes are put on the power of retaining them in that position is soon lost. They also "leak off" very rapidly after being "full on," and the train is no longer under proper control.

Plates Nos. 29 30, and 31.

Hardy's Automatic Vacuum Brake (Plates Nos. 29, 30, and 31).

Description. In Hardy's vacuum brake the ejector used on the locomotive is double, and is so constructed as to be used on the locomotive independently of the carriages. One steam jet only is used, and a single line of pipe also is adopted in this system. In other respects it does not differ materially from Smith's. In Hardy's automatic brake there are reservoirs as well as cylinders under the vehicles, the air from them being exhausted by means of the ejector. The reservoirs have valves attached, by means of which communication is made between the cylinders and the reservoirs, and the ejector is so arranged with a flexible cylinder or sack and a steam cylinder that a vacuum is thereby retained automatically in the main pipes traversing the train.

Mode of working. Before leaving the terminus the engine-driver operates a starting-valve, and creates a vacuum in the main pipes and reservoirs as well as in the small vacuum sack on the engine, the vacuum being generally about twenty-four inches, and in this condition the brakeblocks are released, and continue so until the

Brake on. vacuum in the pipes is reduced to ten inches. Means are provided by which any leakage through the pipes is prevented, and the vacuum maintained. The engine-driver in opening the airvalve seals the vacuum in the small sack, but destroys it in the main pipes and applies the brake; and the same operation can be effected from the guard's van.

Double-acting valve. In addition to the above there is a self-acting double valve attached to the reservoir of each vehicle whereby an automatic action is obtained. This was devised to meet the requirements of the Board of Trade, which insists upon the general adoption of "automatic brakes." The double-acting valve has one end working and sealed by a diaphragm, and the other by a rubber lift-valve, both valves being on one spindle. Upon the vacuum being created in the main pipe leading to the ejector, the diaphragm is drawn outwards, and being considerably larger in diameter than the valve, instantly closes it, and thus prevents the

Brake off. entrance of air into the reservoir, the rubber lift-valve permitting air to pass through holes into the sack or cylinder, thus releasing the brake. This position is maintained until it is necessary to apply the brake, when the engine-driver or guard opens a valve and allows air to pass into the pipe and so destroys the vacuum. The same result would obtain in case the couplings parted by accident or the pipes became damaged.

Plate No. 32.

Clayton's Automatic Brake (Plate No. 32).

The automatic brake known as Clayton's is in use on the Midland Railway, Mr. Clayton being the superintendent of the carriage department on that line.

Description. It consists of an ejector on the locomotive whereby the vacuum is created—of the main pipes A, a vacuum chamber D, a piston C, piston-rod B, and lever E connected with the push and pull rods of the brakeblocks.

Mode of working. By means of a small ejector the air is withdrawn from the main pipe, and from the top and bottom of the piston, through a flexible pipe F, a vacuum of 24in. to 30in. being maintained while running. The brake is operated by a valve connected with the main pipe, which can be opened by the engine-driver or the guard,

Brake on. thus allowing the air to flow to the under side of the piston, and thereby applying the brake.

The

The piston is provided with a leakhole instead of using a valve for opening communication between the upper and under side of the piston. Leakhole.

The act of uncoupling the connections between carriages, the accidental severance of the main pipe couplings, or damage to the pipes themselves causes the brakes to apply themselves to both portions of the train, which is very inconvenient in shunting; and the great disadvantage of the leakhole is that the effect of the brake, once put on, is soon lost, as the air leaks through to the opposite side of the piston, gradually releasing the brake. In fact, on long inclines, similar to those in use in this colony, ten or fourteen miles in length, the use of the vacuum brake would be absolutely dangerous, and could not be rendered effective until it was provided with proper valves in the main pipe couplings, and a valve similar to the triple valve of Westinghouse, adopted in lieu of the leakhole in the piston. This would make the automatic vacuum brake effective; but the simplicity of its original construction would at once disappear, and it would become quite as costly as the automatic air pressure brake. Vacuum brake not suited for long inclines.

Dean & Sander's Automatic Vacuum Brake (Plate No. 33). Plate No. 33.

This brake is used on the Great Western Railway of England, Mr. Dean being the locomotive and carriage superintendent. It is automatic in its action, differing altogether from Smith's brake, inasmuch as the piston is a fixture, and the cylinder moves and operates the brake levers. The following reference letters show the corresponding parts on the diagrams in the appendix:—A, continuous pipe, connected by a flexible pipe between the carriages; B, hollow piston-rod, connected by branch pipe to the continuous pipe; C, piston; D, cylinder, capable of moving freely up and down on the fixed piston, and connected at bottom with the brakelevers E. Description.

The air is exhausted by an ejector on the locomotive from the pipes and cylinders in the train when the train is at rest, and by the airpump when the train is in motion, about 20in. to 30in. of vacuum being necessary. The vacuum being equal on both sides of the piston, the cylinder falls by its own weight, and holds the brakes off the wheels. Action of brake. Brake off.

As soon as the air is admitted into the main pipe, whether designedly or accidentally through severance of couplings, it rushes through the pipe down the hollow piston-rod into the upper part of the cylinder, and pressing the rubber packing against the sides of the cylinder, seals the vacuum on the under side of the piston, so that the pressure of the air causes the cylinder to rise and apply the brakeblocks to the wheels. Brake on.

When the brake is applied, it will remain on until released by exhaustion of air from the upper side of the piston, or admission of air to the under side of the piston. The latter mode being generally used a small leakhole is provided in the end of the piston, through which the air can slowly leak from the upper to the lower part of the cylinder, and gradually release the brake. Release of brake.

In order to apply the brakes on each vehicle as nearly as possible at the same moment, it is necessary to admit air to the continuous pipe in more places than one, and for this purpose a valve or break-setter is provided in each guard's van, so constructed that any sudden increase of pressure in the pipes instantly causes the valve to open automatically and admit a supply of air, after which it closes by its own weight, and by lifting the handle attached to the valve the guard can on an emergency apply the brake to the whole train. Brake-setters.

Vacuum Brake Company's Systems (Plates Nos. 34, 35, and 36). Plates Nos. 34, 35, and 36.

The Vacuum-Brake Company, Limited, make three systems of brakes, systems A and G being automatic, and system C non-automatic, with tell-tale passenger communication.

In system A, Plate No. 34, the brake is worked in the usual manner by an ejector on the locomotive, by which the air is withdrawn out of the main train pipe from the bottom side of a diaphragm in the cylinder under each vehicle, through a branch pipe, and also from the top side of the same diaphragm through a vacuum-chamber and a ball-valve; so that while the train is running a vacuum of 20in. to 24in. is maintained throughout the train. The brake is operated by a valve connected with the main-pipe, opened by the engine-driver or guard, thus allowing air to flow to the bottom side of the diaphragm, and thereby applying the brakes. The top side of the diaphragm and the vacuum-chamber maintain the vacuum through the action of the ball-valve, which closes immediately the air is admitted into the main train pipe. System A. Ball-valve. Brake on.

Should the "universal" hose couplings (a specialty of this company) become detached, which they can without damage, the brakes immediately apply themselves; and to release them when the engine is detached from the train, the ball-valve (by means of a cord placed on each side of every carriage) is opened, and air is admitted to the vacuum chamber and top side of the diaphragm, thus restoring the equilibrum on both sides of the diaphragm, and the brakes, as a consequence, fall off by gravity. It is claimed that for simplicity, efficiency, and durability this brake is unequalled by any other system, there being no parts exposed to friction or requiring lubrication. To release when brakes are applied accidentally.

System G. (Plate No. 36) is also an automatic brake, and is very similar in construction to Clayton's, with the exception that it is fitted with a ball-valve instead of a leakhole. Plate No. 36. System G.

The following letters show the corresponding parts in the annexed diagram:—A, main train pipe; B, piston-rod; C, piston with rolling rubber ring packing; D, vacuum chamber; D1, cylinders; E, levers for working the push and pull brake-rods; F, flexible pipe; G, ball-valve. Description.

The mode of application is similar to system A, but a cast-iron piston with a rubber rolling ring packing is substituted for the diaphragm.

Plate No. 35. System C.

System C, plate No. 35, is non-automatic, and consists of a mainpipe A; of a cylinder D; a piston C; connecting rod B; brakelever E; flexible pipe F; indicator G.

Description. Partial vacuum.

This brake is worked by means of a small ejector (known as a tell-tale ejector), whereby a partial vacuum is maintained in the main train pipe and top of the cylinders connected therewith, but not to such an extent as will affect the brakes. So long as this partial vacuum is maintained the gauge indicates "Brake right"; but should a leak occur of such a nature as to render the brake unreliable, the small ejector fails to maintain the vacuum, and the gauge shows "Brake wrong," so that engine driver and guard are prepared to act accordingly.

Brake on.

To apply the brake the driver pulls the lever on his engine from "Running position" to position marked "Brake on," when the large ejector is brought into play, a high vacuum created, and the brakes applied.

This brake is only one step removed from an automatic brake.

Plates Nos. 37 to 42.

Westinghouse Airpressure Brakes (Plates Nos. 37 to 42).

As this brake is an American invention, a full description of it will be found under the heading "American Railways."

Board of Trade Conditions as to Brakes.

Board of Trade.

The Board of Trade of England have laid down certain conditions with which it is essential that a good continuous brake should comply—

(*a*) That the brakes should be efficient in stopping trains, instantaneous in their action, and capable of being applied without difficulty by engine-driver or guards:
(*b*) In case of accident to be instantaneously self-acting:
(*c*) The brakes to be put on and taken off with facility on the engine and every vehicle on the train:
(*d*) The brake to be regularly used in daily working:
(*e*) The materials employed to be of a durable character, so as to be easily maintained.

Regulations disregarded.

The brakes must also be capable of stopping a train on a level within 275 yards from a speed of fifty miles per hour. Notwithstanding those conditions which were issued on the 30th August, 1877, it does not appear that the railway companies have, up to this time, endeavored to act up to these conditions, and the half-yearly returns, published by the Board of Trade of the brake failures, show very unsatisfactory results. It is much to be regretted that a further conference could not be held between the various railway engineers, at which the relative merits of the brakes which appear to comply with the conditions laid down by the Board of Trade could be discussed, and that brake adopted which best fulfilled those conditions; because by this means the adoption of one kind of brake would allow the free interchange of stock on the various lines, which is now impossible, even on those railways owned by two or more companies, whose lines are continuous.

The following statement, published in the *English Mechanic* for October 12th, 1883, is extracted from the Board of Trade returns up to June 30th, 1883, and shows the amount of rolling-stock in England, Scotland, Wales, and Ireland now fitted with continuous brakes which *appear* to comply with the conditions issued by the Board of Trade:—

Name of continuous brake.	Name of railway company.	Amount of stock fitted.		
		Engines.	Carriages.	Connecting pipes only.
Clarke & Webb's	North London	—	558	—
Sanders and Bolitho Automatic Vacuum	Aylesbury and Buckingham	1	3	—
" "	Great Western	*467	2,360	120
" "	Midland	*449	2,402	513
Smith's Automatic Vacuum	Great Northern	2	12	—
" "	Lancashire and Yorkshire	66	330	21
" "	London and South-Western	133	502	33
" "	Taff Vale	4	17	—
" "	Belfast and North Counties	4	17	40
" "	Great Southern and Western	1	5	—
Steel McInnes	Caledonian	3	29	14
Westinghouse Automatic	Eastern and Midlands	5	33	2
" "	Great Eastern	210	1,737	447
" "	Great Northern	2	14	6
" "	Lancashire and Yorkshire	18	—	6
" "	London and South-Western	2	7	—
" "	London, Brighton, and South Coast	289	2,053	331
" "	London, Chatham, and Dover	14	75	10
" "	Midland	48	85	193
" "	Midland Scotch Joint Stock	—	57	—
" "	North-Eastern	†415	2,617	160
" "	Rhymney	8	24	32
" "	West Lancashire	7	28	—
" "	Caledonian	76	710	483
" "	Glasgow and South-Western	74	255	153
" "	Highland	‡	‡	‡
" "	North British	134	1,199	24
connecting pipes only	East Coast Joint Stock and Pullman cars	—	—	124
" "	Somerset and Dorset	—	—	2
	Total	2,432	15,129	2,714

Note—* The engines have only steam brakes. † Including goods engines. ‡ The Highland Company has a train fitted and working, but omits to give the number of vehicles.

"The

"The total passenger-stock running on these railways consisted, up to June 30th, 1883, of 5,783 engines "and 47,045 vehicles. Of these 3,478 engines and 32,685 vehicles are returned as being fitted with some "form of continuous brake; but, from the preceding return, it would seem that only 2,432 engines and "15,129 vehicles were fitted with brakes which *appear* to fulfill the conditions of the Board of Trade."

Westinghouse brake best fulfils Board of Trade conditions.

It is an extremely difficult question to decide which is the best brake to adopt; but there is no doubt that the brake which acts so as to stop a train in the shortest period of time, possesses one of the principal qualifications of a good brake; because, when an accident is imminent, the rapid stoppage of a train is of paramount importance. From all the information I can gather, I believe that there is no brake in actual work that will stop a train in less time than the Westinghouse, which at the same time better fulfils, than any other brake, all the Board of Trade conditions.

AMERICAN RAILWAYS.

American Railways.

In the United States there are, as in England, a variety of brakes in use, from the ordinary chain brake, worked from the platform of each vehicle, to the vacuum and air-pressure brakes.

Creamer's brake.

There is a brake in use known as "Creamer's brake," which is a very simple device, consisting of an involute spring contained in a drum, which is attached to and acts upon the brake shaft of the cars. Before the train starts the spring on each vehicle is wound up, and retained in a state of tension by a pawl. In case of danger this pawl is disengaged by a lever operated by the bellcord running throughout the train, so that a passenger, conductor, or engine-driver, can at any moment apply the brake; and should a coupling part, and the cars become detached, the brake is automatically applied to every vehicle.

Smith & Eames' Vacuum Brakes.

The "Smith's vacuum" and Eames' vacuum brakes are also used in the States. The Smith's vacuum brake having been previously described, a short description of the latter may be interesting.

Eames' vacuum continuous brake.

The Eames' vacuum continuous brake is worked by the natural pressure of the atmosphere, as opposed to a vacuum created and maintained as required by an ejector or airpump.

Cylinders. Pipes.

It has two cylinders under the engine, two under the tender, and one under every vehicle; also two lines of main train air pipes, with suitable couplings and valves between each vehicle.

One of these main pipes is termed the "automatic pipe," and is connected under each vehicle with a valvebox, which has one connection with a reservoir and another with the cylinder, the valves in the couplings being prevented from closing by special hooks for the purpose. The other main pipe is connected direct with each cylinder, and the valves in the couplings close when the couplings are separated. There are two ejectors—one constantly maintaining a vacuum in the "automatic pipe" and reservoirs; the other, a larger one, for creating a vacuum in the plain pipe when required. There are also valves for admitting steam to the ejectors, and other valves to admit air to the two lines of pipes as well. To work the brake the small ejector is started, and a vacuum is created in the "automatic pipe," valvebox, reservoir, &c. When it is required to apply the brake the large ejector is started, and a partial vacuum is created in the other main pipe and in all the cylinders in the train, a check valve in the valvebox preventing the air from flowing from the "automatic pipe" into the cylinders.

Ejectors.

Working the brake.

Brake on.

Brake off.

In case of train separating, brake applied.

The brakes are taken off by admitting air into the other main pipe and cylinder, by means of a valve under the control of the engine-driver. Should a coupling-chain break between any two vehicles the pipe-couplings come apart, and the valve on the automatic-pipe is kept open, destroying the vacuum in the pipe and on one side of the valvebox diaphragm, causing it to open an outlet between the reservoir and the cylinder, thereby exhausting the air and putting on the brakes.

There is in each brakevan a valve for the admission of air to the automatic-pipe, by which the guard can operate the brake.

The brake is much more complicated than the automatic vacuum brakes used in England, and does not afford any additional security; while, owing to the exposure of the flexible rubber pistons, they are more liable to derangement and damage.

Westinghouse Air-pressure Brakes.

Westinghouse air-brake. Freight-car brake.

The Westinghouse automatic and non-automatic air-pressure brakes are used on the principal railways in the United States on the passenger trains, 192 railroads using the automatic and sixty using the non-automatic brake. The following companies have lately applied the automatic airbrake to all their freight cars, viz.:—The Union Pacific, the Central Pacific, the Northern Pacific, and the Atchison, Topeka, and Santa Fe Railroads. The Westinghouse automatic brake is generally acknowledged by the leading railroad companies to be the most perfect and reliable brake in existence at the present time; and the working parts have been recently so much simplified that there is no longer any necessity to designate any of the mechanism as frail or complicated.

Description.

The brake consists of a steam-engine and airpump, fixed on the locomotive for compressing air:

A reservoir for containing the air thus compressed:

A brakevalve on the locomotive, by which the flow of air is adjusted from the reservoir, and from the brakepipes to the atmosphere:

Main

Main trainpipe, for conveying the air from the main reservoir to the breakvalve, and throughout the length of the train to the auxiliary reservoirs under each car:

An auxiliary reservoir for storing the air required for working the brake on each car:

A brake cylinder, with piston-rod connected with lever and rods to the brakeblocks.

A triple-valve connecting the main trainpipe with the auxiliary reservoir, and the reservoir with the cylinder, and worked by causing a sudden variation in the pressure of air in the trainpipe, admitting it

Brake on. from the auxiliary reservoir to the brake cylinder, thus applying the brake, and at the same time cutting off communication between the main trainpipe and the auxiliary reservoir. It also restores the air com-

Brake off. munication between the main trainpipe and the auxiliary reservoir, at the same time admitting the escape of the air from the brake cylinder, and releasing the brake.

Triple-valve. This valve consists of a brass piston and slide-valve. As soon as the pressure of air in the main trainpipe is reduced, the pressure in the auxiliary reservoir forces the piston of the triple-valve down, and at the same time moves the slidevalve so as to open the passage leading directly from the auxiliary reservoir into the brake cylinder, and applies the brake to the wheels. As soon as the pressure in the main trainpipe is increased above that contained in the auxiliary reservoir, the piston of the triple-valve is forced up, and moves the slidevalve into its former position, allowing the air in the brake cylinder to escape, and releasing the brake from the wheel; so that a reduction of the pressure in the main trainpipe causes the brakes to be applied, and should any portion of a train separate from the rest the air in the trainpipe escapes, and the brake is at once applied to both portions of the train automatically.

Mode of operation by engine-driver. The operation of the brake by the engine-driver or guard is very simple. In the first case the driver moves the handle of his brakevalve to the right, by which he closes the valve that retains the air pressure in the main reservoir, and allows a portion of the air in the main trainpipe to escape, thus reducing the pressure, and applying the brake. By restoring the handle of the valve to its first position, he allows the air in the main reservoir on the locomotive to flow into the main trainpipe, thus restoring the pressure, and releasing the

Graduated application. brake. The engine-driver is thus enabled to graduate the application of the brake from "off" to "full on," and avoid the jerks due to suddenly opening the valve.

By the guard. The application of the brake by the guard is effected by a valve fixed in the van, whereby he can at will allow of the escape of air from the main trainpipe, which reduces the pressure, and causes the triple-valve to open the communication between the auxiliary reservoir and the brake-cylinder. This applies the brakes to

Release-brake. the wheels; and by means of a cord running throughout the train, and connected with this valve, any of the

Locomotive brake-cylinder. conductors can put on the brakes if it be necessary to do so. A release-valve is also fitted to each vehicle for releasing the brake, if it is applied when the engine is detached. Brake-cylinders are also fitted to the locomotives for actuating the brakeblocks on the driving wheels.

Westinghouse signalling apparatus. The Pennsylvania Railroad Company has adopted, after satisfactory trial, the Westinghouse train-signalling apparatus, which consists of a separate line of pipe extending throughout the train, and connected between the cars in the usual way with hose and couplings. In each car is a valve placed where most convenient, actuated by a cord running along the under side of the roof of each car. On the locomotive is a small reservoir, to one end of which is secured a valve called a "signalling-valve." A second opening in this valve leads to the main signal-pipe, and a third to a small whistle on the engine. By means of a reducing-valve, the signal-pipe receives air at a constant pressure of about 15lbs. to the square inch, and the signal-valve has a diaphragm dividing the valve chamber into two parts, the upper communicating with the main trainpipe, and the lower with the small signal reservoir on the locomotive.

When it is desired to give a signal, the valve in the car is opened by pulling the cord, and by this means the pressure in the main trainpipe is reduced. The pressure in the reservoir being greater, moves the diaphragm so as to throw the small valve away from its seat, and allows some of the air to escape from the

Four or five whistles a second reservoir to the whistle on the engine. The action is very rapid, and as many as four or five whistles can be given per second with certainty. If the train separates, the whistle continues to blow until the reservoir is exhausted.

Freight car-brake. The freight-carbrake is now coming into extensive use in the United States, and in its operation is exactly the same as the passenger brake described above, but the mechanism is differently arranged—the brake cylinder, triple-valve, and reservoir are all bolted together. The pump used on the engine is of a larger diameter, supplying about double the quantity of air to that of the passenger engine pump. It is found that it is not satisfactory to work a non-automatic brake on a freight train composed of more than twelve cars, but that it is quite possible, without any difficulty, to work trains of fifty cars with the automatic air brake.

By a simple valve placed on the couplings, in any portion of the train, the engine-driver can apply the brakes on the front section alone, or on both, if he finds it necessary.

Plates Nos. 37 to 42. Full illustrations of the Westinghouse automatic passenger and freight brakes are given in the appendix. (Plates Nos. 37 to 42.)

The cost of the freight-carbrake, as supplied by the Westinghouse Company, is £10 per freight car, the engine fittings £60, and the tender £12 each, with a liberal discount if contracts are made during 1883-4.

Instantaneous in its application. One of the great advantages of the air-pressure brake over any other in use, is its almost instantaneous action, the time occupied in applying the Westinghouse brake to a train of fifteen vehicles being not more than one and a quarter seconds; whereas, with the vacuum brake, several seconds (varying from six to fifteen)

fifteen) elapse before the brake is fully applied throughout such a train, and then immediately afterwards it commences to "leak off." Now, trains running at 30, 40, 50, and 60 miles per hour will travel respectively 44, 58·66, 71·33, and 88ft. in one second. Hence the saving in time by a prompt application of brake power is all important when danger is imminent; and any brake that will "leak off" if left to itself after full application in two or three minutes, which the Midland Railway brake does, is absolutely unsafe for working long and steep inclines.

Distance travelled at varying speed of trains. Danger of the "leak hole."

From a statement just published by the Westinghouse Brake Company, Limited, of London, the following figures are compiled:—

Number of Westinghouse Brakes ordered to July, 1883.

Automatic.

Country	Engines.	Carriages.
England	1,490	11,375
France	1,443	9,164
Belgium (State)	467	2,502
Germany	76	197
Austria-Hungary	4	57
Russia	64	51
Holland	347	1,613
Italy	24	80
Sweden (State)	1	6
India	6	60
New South Wales	106	174
Victoria	3	14
South Australia	1	15
United States	6,189	19,982
Total to date	10,221	45,290

Non-Automatic.

There are also in use on engines 2,633, and on carriages 10,520, non-automatic brakes in America, England, and colonies.

Rapid Increase of Westinghouse Automatic Brake.

	Engines.	Carriages.
Total of automatic brakes to 30th June, 1883, as above	10,221	45,290
Total to July 30th, 1880	3,277	13,502
Increase in three years	6,944	31,788

The above figures illustrate very clearly that the automatic brake of Westinghouse is coming into very extensive use not only in England, but on the Continent of Europe, and will no doubt completely eclipse the vacuum brake, which has hitherto been a formidable rival in England.

Items Nos. 12 and 21.—RAILWAY CARRIAGE LIGHTING AND COMPRESSED GAS FOR LIGHTING CARRIAGES AND BUOYS.

EUROPEAN RAILWAYS.

European Railways.

The old system of oil lamps, with their bad light and dirty globes, still exists to a very great extent on the European Railways; but there are several systems by which the carriages on the Continent of Europe are lighted by gas. Of these the methods of Pintsch, Cambrelin, Sugg and Forster are principally used. In Italy oil lamps of the ordinary kind are used, in which olive oil is burnt in summer, and colza oil in winter, except upon the trains running through the Mont Cenis and St. Gothard Tunnels, where compressed gas is used.

Pintsch System.

Pintsch system.

The gas used is produced by retorting mineral oils and freeing them from tar and other impurities. The retorts, which are usually in pairs, are capable of generating from 100 to 200 cubic feet of gas per hour. The gas, after passing from the retorts, is compressed by powerful forcepumps to about 150lbs. or 160lbs. per square inch, and forced into suitable wrought-iron cylindrical reservoirs.

Under each carriage one and frequently two reservoirs are fitted, about 9ft. or 10ft. long, and from 18in. to 21in. in diameter, made of $\frac{5}{16}$in. iron plate, riveted and soldered together, and tinned both inside and outside.

These reservoirs are supplied by means of a main pipe, laid under the station platform, fitted with branch cocks and hoses at suitable distances, corresponding with the position of the reservoirs under the carriages. The pressure at which the gas is delivered into the carriage reservoirs is about 90lbs. per square inch, and the time required to fill a train is about one minute. The gas is also conveyed in large portable reservoirs, mounted on trucks, to those portions of the line where the consumption is not very great, or where it is impossible to erect the necessary gasworks. The cost of the refined paraffin oil, from which the gas is made, is about £6 10s. per ton in London. In order to regulate the pressure of the gas as it passes from the reservoirs at a pressure of 90lbs. to the burners, where it is reduced to about 1½in. of water, a cast-iron pan 10in. in diameter by 6½in. deep is fitted; and under the lid or cover a gasproof leather disc, to which is attached a rod suspended from the centre, and connected at one end with a lever, acted upon by a spring. The gas entering

Train filled with gas in a minute.

entering the pan depresses the lever by acting on the disc, which, being governed by the spring, regulates the admission. The lamps are similar to the ordinary carriage lamp in appearance, with the exception that they are fitted with a white porcelain reflector, and the admission of air from the interior of the carriage is prevented, thus protecting the light from being affected by the draughts of air entering through the open windows and doors.

Cost.

The cost of the necessary works for making the gas depends upon the number of furnaces required, as the following figures show:—

	Furnace and compressing machinery.
	£
One furnace and retorts for producing gas sufficient for a jet to burn 300 hours	345
Two furnaces, equal to supplying a jet for 2,500 hours	720
Three furnaces, equal to supplying a jet for 7,500 hours	1,000
Four furnaces, equal to supply a jet for 12,500 hours, exclusive of buildings	1,870

The cost of fitting up each carriage will be in proportion to the lights employed:—For a two-light, £22; for a three-light, £25; for a four-light, £28; for a six-light, £38. The travelling reservoirs cost about £9 10s. each, and are capable of containing eleven cubic feet of gas, which will supply a jet for about ninety-six hours.

Costs 0·12d. per hour per light.

From returns given it has been ascertained that the cost of each light, including interest and repairs, is about 0·12 penny per hour. Since I left England I am informed that the Midland Railway Company has decided to have all their passenger-stock fitted with Pintsch's system of gas.

Date of introduction of system.

Number of carriages fitted.

Pintsch's system has been in use in Germany and on the Continent of Europe for about nine years, and in England about five years. It is in use on sixty-three lines of railway on the Continent, forty-five gasworks being required for supplying no less than 5,500 carriages. In England the system is in use on five railways, viz.:—The Great Eastern, South-Eastern, South-Western, Metropolitan, and Metropolitan District, having seven gasworks in operation and 1,000 carriages running, with 300 more being fitted.

Cambrelin System.

This system is used on the Belgian State lines of railways, and the works are situated at the North and Midland stations in Brussels.

Cambrelin system.

The gas is manufactured by distilling boghead, petroleum, and paraffin.

The gas generated from the boghead is purified after retorting, and washed with water, and conducted to a mixer, where the three gases are combined under a pressure of 1¼in. of water. After thoroughly mixing it is compressed to 150lbs. to the square inch and forced into wrought-iron receivers.

The quantity of gas generated from boghead is	1,555	cube ft.	per	220lbs.
" " " petroleum	2,100	"	"	
" " " paraffin oil	2,100	"	"	

	£	s.	d.		
The price of boghead	2	18	10	per ton	
" petroleum	0	15	0	per 100 kilos	(220·5lbs.)
" "	0	10	6	"	"

In the van attached to the train are placed two connected reservoirs, containing about 700 cubic feet of compressed gas, at a maximum pressure of 120lbs. per square inch. By means of a supply pipe taken along the carriage roofs the gas is conveyed to a regulator of a similar kind to Pintsch's, except that the diaphragm is made of gold-beater's skin instead of leather, and by this regulator the pressure is reduced to about 1¼ths of water, giving a constant supply by a further reduction in the burners of 0·6in. The burners consume about 0·9 cube feet of gas per hour. In another van is placed an auxiliary flexible reservoir worked under a pressure of 16ft. of water, by means of which the burners in the rear portion of the train are kept burning when it is disconnected.

Cost of fitting carriages. Cost of burning.

The average cost of fitting up the carriages with this system was £7 per carriage, and the gas consumed cost from 0·32d. to 0·72d. per burner per hour.

Forster's System.

Forster's system.

The Forster system has been used in America for carriage-lighting and lighthouse illumination since 1874. The gas is generated by retorting crude petroleum, and is compressed up to 150lbs. to 170lbs. to the square inch, the principle being very similar to that of Pintsch's.

ENGLISH RAILWAYS.

English Railways.

Sugg's System.

Sugg's system.

This system consists of mixing ordinary coal gas with the gas made from petroleum in the proportion of three to one.

The Great Northern Railway erected an apparatus for this purpose, consisting of two connected retorts placed above a furnace. Into the upper one, which is jacketed with water space, iron filings are placed; the

the heat being kept about 212°, and never beyond 302°, Fahrenheit. In the lower retort the heat is kept at from 572° to 1,800° Fahrenheit. The coal gas and petroleum gas are conveyed by separate pipes into the upper retort. On the roof of each carriage is fixed a pair of cylindrical reservoirs, 19ft. long by about 12in. in diameter, holding about fourteen cubic feet of gas, which is conveyed thence by pipes to a regulator consisting of a cast-iron box, having a reservoir within it with flexible sides, and a metal cover and two spiral springs between the cover and top of the cast-iron box. The admission of gas is regulated by the tension of a spiral spring connected with a slotted lever.

Pope's System.

Pope's system.

This system is only used in England. The gas is made from shale, or other similar oils, distilled in retorts set in pairs, and connected at one end. The oil is fed slowly into the retorts after heating, and is decomposed into gas at the rate of 100 cube feet to the gallon of oil; it then passes into the hydraulic mains, and thence into a condenser and scrubber, and finally to a reservoir, from which it is pumped and compressed to about 150lbs. per square inch. Suitable mains and branches, with valve couplings and hose pipes, are laid under the platforms for charging the carriage reservoirs.

On each carriage one or more cylindrical iron reservoirs are fixed, which supply the burners after passing by means of piping through a regulator for reducing the pressure. A pressure-gauge is affixed to each carriage to enable the porters at all times to see what pressure they have in the reservoirs. There are also handles placed at the end of the carriage for the purpose of enabling the guard to extinguish all the lights when necessary.

Cost.

The gas produced by this system is entirely free from smell or smoke, and is permanent, and costs in England about eleven shillings per 1,000ft. to produce.

The London and North-Western Railway Company are running a train of carriages, containing seven lamps lighted by this system, a distance of 1,050 miles, from Euston to Aberdeen and back, with one charge of gas. The lamps are usually regulated to burn five-tenths of a foot per hour, and the cost is ·07d. per lamp per hour. Besides the above company the Lancashire and Yorkshire, the Great Western, the Caledonian, South-Eastern, Great Northern, and Manchester, Sheffield and Lincolnshire, are using and testing this system.

With coals at 28s. per ton the gas can be made for 12s. per 1,000 cubic feet, equivalent to a light burning fifteen hours for one penny. The oil is estimated to cost 6d. per gallon, labor 5s. 6d. per diem, and say fifteen per cent. for depreciation and wear and tear.

I. The cost of fitting up carriages completely, each lamp to consume six-tenths of a foot per hour, and the carriages having reservoirs to contain sufficient gas for thirty hours continuous burning, is £6 10s. per lamp for four lamps, plus fifteen per cent. f.o.b.

II. The cost of a complete plant for making gas sufficient to supply twenty carriages, but capable of being enlarged to supply 100 carriages, will be £400 11s. 9d. f.o.b.

III. The additional plant to supply 100 carriages, £670 9s. 9d. f.o.b.

The first estimate has a 3in. compressing pump, worked by a hand or by a belt. The second estimate has a 4in. compressing pump, on a cast-iron bed, driven by wheel and pinion fly-wheel and pulleys for a belt. The cost of a four-horse power compressing pump and boiler, complete, would be £160 f.o.b. Fire tiles and lumps £2 10s. per set.

The plant, as estimated for above, has ample capacity for 250 carriages, by simply adding more retorts. The manufacturers are Messrs. Pope & Sons, 190, Edgeware-road, London W.

The adoption of gas not universal.

Notwithstanding the unqualified success attending the introduction of the system of lighting carriages with gas, it has not yet been adopted by the various railway companies in England and on the Continent to the extent that was anticipated. This is possibly attributable to motives of economy on the part of the railway companies not wishing to incur the expense of providing the plant and changing all the lamp stock. The use of mineral sperm oil in lamps suited for the purpose is carried out to a very limited extent in England, where the travelling public on many of the railways have to put up with the wretched apology for a light obtained from the old fashioned oil lamps.

The "Pintsch" system of lighting is in more general use than Pope's, and I am inclined to think the light of the former is the brightest and clearest. The Pintsch system has been largely employed for lighting buoys, and I will briefly describe and illustrate one of them.

Pintsch's Patent Gas Illuminated Buoy.

Pintsch's gas buoy.

Plate No. 23.

An illustration of one of these buoys, as used by the Trinity House, is given in the appendix, Plate No. 23.

The gasworks used for making gas for these buoys are of the same character as those used for carriage-lighting; but are, of course, much smaller.

Cost.

The cost of a gas buoy of the size and description illustrated, with lantern, lens, valves, and fittings, f.o.b. Thames, is £420, including all royalties and patents. It burns with one charge of gas continuously for two months without any attention whatever.

The

The machinery required for turning out compressed gas for almost any number of buoys is about £500, f.o.b. Thames. Duplicate machinery about £1,500. The consumption of gas per hour is 0·7 of a cubic foot; and the light in England and Scotland is visible for six miles, and in Egypt and other dry climates, it can be seen at a distance of ten miles.

Clyde Trust. The Clyde Lighthouse Trust report that they have tested one of these buoys for fifteen months, during which period it has been constantly burning; and notwithstanding the severe gales of the winter of 1881, the light was not affected in any way.

Trinity House. The Trinity House also report that a gas buoy, on Pintsch's system, has been burning for some months at the East Oaze station without intermission, and that the light was visible from the lightship 1¼ miles distant in bad weather, although the buoy itself was at times hidden from view by the spray of the sea. This buoy was 9ft. diameter, contained about 314 cube feet of gas, and from 18th April to 28th November, the date upon which it was damaged by being run into by a passing vessel, the light on it was always visible.

Havre. On the 3rd of October, 1881, a buoy of this description was anchored off Havre, and lighted, and the light went out for want of gas on the 30th January, 1882, having burnt 2,839 hours continuously. The capacity was 351 cube feet, and the gas at the commencement was under a pressure of 90lbs. to the square inch, the rate of consumption being three-fourths of a cube foot per hour. The light, which had a red tinge purposely given to it, was visible for a distance of five miles, and had the same intensity at the end as it had when first lighted. It was seen ninety-three times in 100 various positions in Havre at one and one-quarter miles to two and a half miles distance; and sixty-three times in 100 at La Hève two and a half miles distant. It was during the above period exposed to three heavy storms without any injury resulting. The photometric experiments on shore indicated that the light equalled one and a half carcel. This buoy cost about £410, exclusive of chain and anchorage. The yearly cost of lighting is £8 10s., but to this must be added the cost of maintenance and periodical filling.—Extract from Min. Pro. Inst. C.E., vol. 70.

Kohinoor gas apparatus. In addition to the above I was shown, when in London, a very excellent apparatus for generating gas suitable for railway stations, &c. Kings-Langley and Finsbury Park stations are lit with this gas, as well as stations on Lake Maggiore, in Italy. The gas is made from crude petroleum or shale oils, and is quite

Cost. pure and free from noxious vapors, and containing no sulphur or carbureted hydrogen. The cost of the double-retort apparatus, which, exclusive of the gasholder, does not occupy more than 6ft. square, and is capable of generating gas for any number of lights if generated continuously, is £90, exclusive of steamboiler.

	£
One retort only, including royalty	35
Two " "	55
Three " "	70

Fixed in brickwork instead of iron casing. The special burners are one penny each. As steam is used in the generation of this oil, the gas does not clog the pipes or retorts.

The prices of boilers fitted are as under:—

	£
For 100 lights	15
" 200 "	20
" 500 "	25
" 1,000 "	40

Royalty, which is perpetual, is—

	£
For 200 lights	20
" 500 "	30
" 1,000 "	40

The gas produced by this machine in England costs 1s. 9d. per 1,000 cubic feet (coal gas standard). One hundred feet of 60-candle gas, or 400ft. of 15-candle gas, can be made from a single gallon of oil, costing 3½d.

AMERICAN RAILWAYS.

American Railways. The lighting of the railway cars in the United States is very satisfactory, the light being usually obtained by burning mineral sperm oil in lamps specially constructed for the purpose, and fitted in such a

Carriage-lighting. manner as to thoroughly light the carriages. The design of the car-lamps, which are generally suspended

Cost of lamps. from the roof of the carriage, is very good, but expensive, many of the lamps costing from £6 to £8 each; the average price being about £3 10s. to £4 4s.

Compressed gas. Compressed gas is used on many of the principal lines of railway, and in the stations, the system used being similar to Pintsch's.

Item 13.—RAILWAY COMMUNICATION BETWEEN PASSENGERS AND GUARDS.

ITALIAN RAILWAYS.

Italian Railways.

No communication exists on the Italian lines between the passengers and the guards of trains.

FRENCH RAILWAYS.

French Railways.

The same remark applied to the French railway system.

ENGLISH RAILWAYS.

English Railways.

On the Great Western Railway the electrical communication of Mr. Spagnioletti is used. This system consists of fitting each carriage with two insulated wires carried through each end, so as to enable them to be connected with the contact boxes and the cable between the carriages.

Spagnioletti's system.

There are contact pushes fixed in each compartment over the windows, which can be pushed outwards when desired by a passenger should he require assistance. The pushes cannot be re-set by the passengers, and the call-bell in the guards' van will ring as long as the push is outwards.

The bell, battery, plunger, and switch are fixed to the van. There is also a bell and indicator for the engine.

Six of these instruments were imported by the Engineer-in-Chief's Department of this colony about six years ago, and one or two have been fitted to the local trains running out of Adelaide.

Preece's system.

Preece's electrical communicator is also used on the English lines. It consists of a commutator fixed in the carriages, a battery and bell, &c., in guards' van, an engine signal, and couplings.

Each van has a communicator, so that each guard can communicate with the other and the engineman, and between each carriage a double connection is made, in case one should fail at any time.

The commutator has two faces, and is fixed in the partition between two compartments, so that it can be used from either side. The face is usually covered with glass, which must be broken before the handle, which rings the bells can be reached. This handle, when once used by a passenger, cannot be restored by him to its normal position; but requires a key, which is in the custody of the guard.

The engine signal is a bell, with the armatures inclosed in a case, the face of which has a flap fixed to it, so that, when the bell has rung, the flap falls, and the word "stop" is at once visible to the engineman. This system was first introduced on the London and South-Western Railway.

Walker's system.

There is yet another system known as "Walker's," which is very similar to "Preece's." It was introduced on the South-Eastern Railway. These two systems may be taken as representing those practically in use in England.

Brighton system.

On the Brighton system, Mr. Stroudley has applied electrical communication between passengers and guards. The battery and brackets, signal bells and pulls, for the vans are all contained in a portable case which is simply slid into position in the same method as in fixing a headlamp. The guard can telegraph from one end of the train to the other, and guards (when there are two) can communicate with one another. A passenger can pull the indicator, but cannot stop the bell from ringing until the guard disconnects it with a suitable key. The communication is made throughout the train by an insulated cord, fitted with proper couplings. Any passenger pulling the bell communicator, will set the bells ringing in each van, and the guard must then ring the bell on the engine by pulling the cord communication.

Communicator.

AMERICAN RAILWAYS.

American Railways.

In America there is but one method of communication in general use, and that is by means of a bellcord or rope attached to a signal-bell on the engine, and extending throughout the whole length of the train. In passenger trains the cord is attached by hangers to the inside of the roof of the cars, but in freight trains it is placed outside. The cord is made of flax or hemp, sometimes brass wire covered, and is in lengths equal to that of each car, fastened together with coupling hooks.

Bellcord.

As the American passenger cars are all made with platforms, and free communication exists from one end of the train to the other, the conductor or any passenger can ring the engine bell and stop the train at any time, but the fact that the cord is exposed to the view of all the passengers in each car acts as a deterrent to persons using it for needlessly stopping the train.

Item 14.—RAILWAY BLOCK SIGNALLING (ELECTRIC) AND INTERLOCKING ARRANGEMENTS ADAPTED TO SINGLE LINES.

Electric Block Signalling.

EUROPEAN RAILWAYS.

European Railways.

Block signalling consists of dividing a line of railway into suitable sections, each controlled by signals in such a manner that only one train can be on any one section at the same time. By this means the trains are separated by an actual measure of distance, and not by intervals of time, which are rarely correct—though that plan obtained before the block system was introduced. The

Trains separated by measure of distance.

The ends of each section of the railway are protected by suitable signals visible to the engine-driver by day or by night.

Electric block.

At each station electrical block signalling instruments are fixed, communicating with the sections on each side, and these instruments are so designed as to render it impossible for the person to whom the signal is sent to in any way alter it. At all the termini, junctions, and important stations of railways with a large and frequent traffic, the outside signals are worked in conjunction with the electrical block signals in the cabins in such a manner that, by combining them, the semaphore or outside signal cannot be altered from "danger" to "all right" until the "all right" signal given by the electrical instruments has been received from the station in advance; and the signalman at the advance station is unable to give the electrical "all right" signal until he has placed the arm of his semaphore signal to "danger."

Magneto-inductors.

Messrs. Siemens Bros., of London and Berlin, have perfected the system of electrically controlling the outside signals, and working them in conjunction with the electrical block signals in the cabins. The Messrs. Siemens use magneto-inductors instead of voltaic batteries for working the electrical apparatus, and as these inductors are powerful and constant, and do not require much maintenance, they are better adapted for railway signalling than batteries. On many of the English railways the electric control of the semaphore signals by the block signal has not been brought much into use; but no absolute interlocking block system is complete until this is done. This system is much used on the Continent of Europe; and if introduced on the English railways would no doubt tend to considerably lessen the number of railway accidents.

ENGLISH RAILWAYS.

English Railways. Systems in use.

There are several systems at present in use on the English lines, and among others may be mentioned Tyers', Preece's, and Spagnoletti's; but Preece's system appears to be most in demand. Many of the companies still adhere to the old systems, not because they are the best, but because they do not think it expedient to change a system with which all their employés are familiar.

Block apparatus for station entrance.

Block apparatus is also used at large station entrances for the purpose of preventing trains from entering a station without the consent of the person in charge. It is usually combined with a second apparatus, which is fixed in the distant signal-box, and is interlocked with the distant signal in such a manner that the semaphore arm cannot be lowered until an "all right" electrical signal has been received from the officer in charge of the station.

Spagnoletti's system.

Praed-street station. Automatic.

The system introduced by Mr. Spagnoletti, the electrical engineer of the Great Western Railway of England, has been in use on the South Australian Railways for many years, and has been found simple and effective. When in London I went with Mr. Spagnoletti to the Praed-street station (underground line) to see his system of interlocking by electricty. In the cabin are six levers, one, the controlling lever, was automatically and electrically locked and unlocked by a passing train. Once the lever is locked by the signalman at the forwarding station it cannot be unlocked until the arriving train has cleared the platform—it is impossible for two trains to be in the same section on the same line at the same time. For double lines the signal cannot be lowered for a train to leave a station until the controlling lever has been unlocked by the signalman in advance; and when the train has left the station, and the signal been replaced at "danger," it cannot be again lowered to admit another train until the train has arrived at the station in advance, having itself automatically reset the apparatus. This system has been in use at Praed-street, and on the Great Western

Positive block.

line, for more than twelve months, and is about to be used on the Great Northern Railway. It is a positive block system between any two stations or points required, and is well adapted for controlling from a station any intermediate siding point levers which are required to be worked by the consent only of the station signalman, either in advance or in the rear of such sidings. The apparatus is strong, not liable to derangement, and not expensive, and only one line wire is required.

Spagnoletti's electric lock.

The lock is a steel hook bolt, which pivoting on a half-inch steel pin, hooks into a recess made in the catchrod of the controlling lever, and it is sometimes applied in the form of a direct wedge or plug between the top of the detent of the catchrod and the guide immediately above it.

Automatic apparatus.

The manner in which the train automatically works the electrical contact is by means of a treadle, which makes and breaks the electrical contact by acting upon a flat steel spring, bolted to the sleepers outside the rail in such a manner that the projecting tread of the wheel in passing along the head of the rail depresses the spring and actuates the lever or treadle. The spring being wide also protects the lever from being interfered with or altered by unauthorised persons.

Electrical repeaters for semaphores.

The signal-lamps attached to the semaphore signals of the main stations on the Great Western line were fitted with repeaters, consisting of a box fitted to the signal-arm in which was placed a disc of metal immediately over the lamp-flame, so that the heat from the flame expanded the disc, and indicated by electrical connection with the signal-box "lamp in"; and should the lamp go out by neglect or accident, the metal disc contracted, and electrically communicated the fact to the indicator in the signal-box. The position of the semaphore arms is also recorded by electrical repeaters, acted upon by two springs and a lever attached to the centre pin of the arm in the usual manner.

Harper's patent interlocking block telegraph.

On the Lancashire and Yorkshire—London, Brighton, and South Coast—London and North-Western Railways of England—the Midland, Great Western of Ireland—Dublin, Wicklow and Waterford, and Sligo, Leitrim, and Northern Counties Railways—Harper's patent interlocking block telegraph apparatus is used for preventing errors in signalling trains. The system is a "one wire" system, by which it is rendered impossible for

for the signalman, by mistake, to press the "line clear" plunger instead of "line blocked," as by so doing he would clear the line at the rear of the train, and possibly cause an accident. The reports of the Board of Trade show that this has frequently been done, and Harper's apparatus has been specially designed to prevent such mistakes. This is accomplished by giving to the signalman a positive record of what he has done, so that he can at once see the last signal sent to the rear station; and as the interlocking principle is effected by means of a slotted bar, any number of plungers, keys, or tappets may be locked up, leaving only those free which cannot give contrary signals.

Signalman has positive record.

It is impossible that a signalman can alter or in any way tamper with these instruments, either wilfully or through inadvertence.

Cannot be tampered with.

The interlocking instruments are especially useful at junctions, as it is impossible for the signalman, after he has cleared the main line train, to clear a branch train at the same time, and *vice versa;* one or the other must be locked, and remain so, until the traffic is diverted, thus insuring the greatest amount of security in the working of the junction.

Interlocking instruments for junctions.

The instruments are manufactured by Garnham & Co., Sash-court, Wilson-street, Finsbury, London, who also are the sole makers of Stroudley's electrical communication between passengers and guards, as used on the London, Brighton, and South Coast and Victorian Railways.

Railway bell alarums are much used on the Continent as a means of signalling trains from one station to another, signalling for help from intermediate points between stations, and for signalling the approach of trains at tunnels, level crossings, &c. They are connected by a wire with the stations on each side, so that the departure of a train from either can be at once signalled to the man in charge at the gong. Upon receiving the signal the lineman is aware of an approaching train, and is enabled to communicate automatically from his gong with the nearest stations if he requires to do so. The apparatus being very simple, an ordinary laborer can work it. In Germany, Austria, and Denmark the adoption of gong signalling is compulsory upon the railways, and it is in extensive use in France, Italy, Russia, Belgium and Turkey, there being no less than 38,766 gong alarums in use, averaging 137 gongs for every 100 miles of railway.

Pillar-gong, or railway bell alarums.

AMERICAN RAILWAYS.

The system of working the "block" on American Railways is confined to those main lines upon which there is a large amount of traffic.

American Railways.

Union Switch Company's System.

The signals in use on the Pennsylvania Railroad, which is the best managed line in the States, is that introduced by the Union Switch and Signal Company of Pittsburg. By this system the passing train automatically operates through rail or wire circuits, and sets or reverses signals in front and rear, or both. This company uses the electric locks of Jackson, Rousseau, & Sykes, by which it is impossible for signalmen to alter a switch, or give an "all right" signal to a train coming from the opposite direction after the approaching train has arrived at an "all right" distant signal.

Union Switch and Signal Company.

On double lines the line is divided into "blocks" of a mile in length, or less, and is insulated at each end, a battery being placed at one end and a signal at the other. The pole of one battery is connected to each rail, and they in turn to the signal magnets. There being a constant current through the rails and magnet, the signal is held to "all right" by attracting the armature of the signal magnet. As soon as a train enters the block the current is short-circuited by the wheels and axles of the train, demagnetising the signal magnet, releasing the armature, the signal flying to "danger," and remaining in that position as long as there are any wheels on the block sections. The switches are connected to circuits through a switchbox, and when the switch is open the current is diverted, and the signal flies to "danger." Portions of sidings fouling the main line are also included in the current, so that any vehicle standing on the sidings in such a position as to be unsafe to passing trains will set the signals on the block section to "danger" until the cause is removed.

Automatic electric signals for double lines.

Current short-circuited by wheels and axles.

Portions of main line sidings included in circuit.

Whenever the switches are set for a siding, and a train takes the siding, the signals on the main line not only stand at "danger" but continue to do so until the rear end of the train has passed clear of the fouling point. Any accident caused by a broken or displaced rail, a trolly or vehicle of any kind left on the line, a bar laid across the rails, or any defect by which the line is rendered unsafe, will cause the signals automatically to fly to "danger," and remain so until the cause is removed.

Sidings.

Defects in the rails cause signals to fly to "danger."

On single lines the system is precisely the same as that used for double lines; but two sets of signals are used—those on one side for "down" trains, and on the other for "up" trains. A train in any block section holds the rear signal at "danger," and also holds the advance signal at "danger" in the next section, by which trains are controlled when moving in a contrary direction. Trains are, in fact, by this system, protected in the rear and in advance from collisions. This system, as applied to various purposes, is fully illustrated in appendix, Plates Nos. 43, 44, 45, and 46.

Single lines.

Plates Nos. 43, 44, 45, and 46.

Figure 1 illustrates one line of a double track, with two signals to each block, the secondary signal being operated by the primary, and serving the purpose of an over-lapping signal. In this system the primary signal turns from safety to "danger" at the moment the engine is passing it. It can be supplied at the rate of £90 for each half-mile block, or £95 for blocks over half a mile to a mile in length, having two signals to each block.

Figure 1, double line, two signals to each block.

Cost.

Figure

Figure 2, one signal to each block. Cost.

Figure 2 illustrates one signal used to each block of double line. In this case the engine passes the signal at "safety" and turns it immediately to "danger" on entering the section to which the signal belongs. This is the simplest current in use, and can be supplied at the rate of £55 for half-mile blocks, or £60 for block of half a mile to a mile in length.

Figure 3, two signals to each block. Cost.

Figure 3 illustrates a single line requiring two signals to each section, except the end sections, which require three signals each, in order to provide a "danger" signal at the rear immediately after entering the section. This system can be supplied for £100 per block, including two signals and all materials for each block, and £130 for the end blocks, requiring the three signals to each section. If the company do not supply the line wires, batteries, underground wire or tubing for the same, the price would be reduced by £10 from the above in each case.

Figure 4, drawbridge circuit.

Figure 4 illustrates a special circuit arranged for a drawbridge at Pascagoul on the Louisville and Nashville Railway.

Figure 5, drawbridge.

Figure 5 illustrates a special circuit for a drawbridge at Logansport, on the Pittsburg, Cincinnati, and St. Louis Railway.

Figures 6 and 7, tunnels.

Figures 6 and 7 illustrate special circuits arranged for tunnels.

Disc signals.

The arrangement of signals is a very good one, and consists of a circular iron frame, about 3ft. diameter, carrying a pivoted ring in which is fitted movable iron slats hung in such a manner as to allow the wind to have free passage through, thereby removing the tendency to turn the ring or disc from its proper position.

Lamp.

The lamp for night signals is placed on the top of the iron frame on a box containing the mechanism for moving the signal, which is effected by a chain and weight; and, in order to prevent any accident occurring from the neglect of the signalman in omitting to periodically wind up the weight, the signalman cannot open the lamp-door to light the lamp for night service until he has first wound up the chain. The lamp is in duplicate, as also are the bullseye lenses, both of which are white, and attached to the spindle of the movable disc are two red glasses for showing a danger signal. The duplication of the burners in the lamp, which only shows one light at a time, although there are two distinct and separate burners, is adopted to minimise risk. In case the wind should blow one of them out there would still be a signal light visible, as it is extremely improbable that both lights could be simultaneously blown out. The electrical contact with the magnet is made and broken by the current passing along the rails to a relay, and the mechanism for moving the signal is put into action each time the contact is made or broken.

Lamp has duplicate burners.

Electrical contact.

Level-crossing Bells.

Level-crossing bells.

Near level crossings, on the single-track system, there is a bell on each side of the highway which is rung by the train approaching from either direction, and only rings while the train is within a certain distance of the crossing. The train itself by its action on the rails sets the danger signals in its rear and prevents rear collisions.

Schaffer's Electric Signals.

Schaffer's system.

This system is worked by the Safety-lock and Signal Company of Camden, New Jersey, and is said to be an absolute and effective preventive, under all conditions, of collisions, without the intervention of human agency.

Description.

At certain fixed points on the line iron boxes containing a magnet and armature are placed, the alternate magnets acting in unison, forming thereby a complete interlocking block system. The boxes are electrically connected, and also work by gravity in order that any failure of the electric current may be at once made known to the engine-driver, so that in the event of a switch being wrongly set, or another train being upon the line, a projection in the box is locked into such a position that it strikes an arm or lever attached to the locomotive, and operates on the regulator, the whistle, and the brake. When the line is clear for the two blocks and the train enters the first, the block is locked in the rear and prevents another train from entering by making the arm alluded to above rigid, and at once checking the train, and simultaneously the arm in the second box in advance is made rigid and locked in position to check a train approaching from the opposite direction. In passing the third box the rear vehicle causes an electric current to be completed and released in the first box for a following train. Drawbridges and switches are operated in the same manner.

Interlocking Apparatus, &c.

FRENCH RAILWAYS.

French Railways.

At all important stations and junctions on the French Railways locking apparatus has been introduced to a considerable extent; but its use is confined only to stations having a large and complicated traffic.

Vignier's system

The first system of interlocking introduced on the French Railways was invented by M. Vignier, of the Western Railway of France. It consists in connecting with each lever, near to its lower extremity, a flat bar placed edgeways sliding horizontally in front of, and advancing and receding with each movement of, the lever. In this bar, at certain distances, are punched circular holes to allow of the passage of round pins or bolts which are actuated in a direction across the line of action of the levers, and longitudinally with the lever-frame, thus locking the further progress of the sliding-bar, and with it that of the lever. The locking-bolts are attached by means of a bellcrank to the flat sliding bar of that lever which it is desired to retain, or lock another in a certain position.

Messrs.

Messrs. Saxby & Farmer's interlocking gear is also much used on the Continent, and is preferred to that of any other maker. Saxby & Farmer

ENGLISH RAILWAYS.

The systems generally in use in England are those perfected by Messrs. Saxby & Farmer and Messrs. MacKenzie & Holland. There is in this colony a complete set of levers controlling the crossing of the Nairne and Glenelg Railways made by the latter firm. It has been at work for the past two and a half years, and has given every satisfaction. English Railways.

I saw another very good frame for interlocking, patented by Mr. Jos. Tweedy, of Carlisle. It is extremely simple, the bolt being behind the lever, and inserted into a bolthole in the underside of the segment. The same "key" lever is made to interlock, backlock, and release any number of levers, and the same bolt that completes the interlock effects the backlock when required. Tweedy's Patent

Messrs. Siemens have introduced a very effective "locking-box," by means of which switches are so worked that their position must be in strict accordance with the signals shown by the semaphore; the switches being first set right for the passage of any particular train before the "all right" signal for this train can be given, and as long as the signal is in that position the switches cannot be altered. Siemen locking-box.

The system of interlocking switches and signals on the Great Western Railway of England differs in detail from the plans of Messrs. Saxby & Farmer and McKenzie & Holland. The levers actuate a flat bar having one end twisted into a short spiral and actuated by a pair of forked rollers attached to the lever, the other end of the bar having a pinion keyed in by which the requisite horizontal movement is given to the locking bars. This apparatus has worked well for many years, showing little sign of wear and tear, and is not so heavy in first cost as most of the other systems in use. Great Western system.

The Midland Railway Company use special locking gear of their own design, manufactured at their workshops in Derby. The signals are also made by the company at their works.

The Manchester, Sheffield and Lincolnshire Railway Company use Saxby and Farmer's and Stevenson's locking gear, which together with the signals is manufactured at the Gorton Works.

The application of the interlocking system has been in use in this colony for many years, one of the first frames erected having been made by Messrs. Ransome & Rapier; and as the extension of our railway system has been very rapid, it is well to consider the advisability or otherwise of extending the use of this safety appliance beyond the principal stations or junctions where the traffic warrants every safeguard being provided. In order to illustrate my meaning I could not do better than quote from one of the text books of science—"Railway Appliances," by John Wolfe Barry, Esq., Mem. Inst. C. Engrs., published in 1878. Interlocking system as applied to railways in South Australia.

Speaking of the cost of the precautions that should be taken to protect the travelling public, Mr. Barry says, in pages 181-2—"It must, however, be borne in mind that in endeavoring to guard against every "danger, one can '*buy gold too dear;*' for if every possible known precaution is to be taken, regardless of "cost, it may not pay to work a railway at all. Not only should economy be studied in the design of safety "appliances (and the more costly arrangements are not always the best), but there should be a proper "adaptation of the work to the requirements of the situation. Thus, precautions which are most necessary "for a heavily worked portion of a railway are, on a wise consideration of probabilities, superfluous on a line "with small traffic. Cost of precautions.

"It is, however, common to hear the argument that every known means of ensuring safety ought to be "everywhere taken. Within limits this is no doubt reasonable, but the concession of the principle must "be carefully and largely qualified. It must be borne in mind that the adoption of new appliances in dealing "with so complicated a problem as that of working a railway must, or ought to be tentative, for there are "many promising contrivances which turn out after trial to be unsuitable, and an ingenious plan for "getting over one difficulty may produce another, and, perhaps, a worse evil. Moreover, granting that none "but suitable inventions are included in the consideration, it is simply impossible to carry out literally the "demand, that they should all be adopted; for there is no limit, except the cost, to the amount of precautions "that might be applied to any railway; and signals, signal stations, and telegraphic checks of all sorts "might be multiplied to any extent, even on the most insignificant branch. The amount and nature of these "precautions must inevitably be, to some extent, limited by the question of money, and the possibility of "working a remunerative traffic; and it is thus highly important that whatever money is spent should be "spent in a judicious manner, and where it is most wanted, rather than in applying a certain set of pre-"cautionary measures uniformly in every situation and all over the railway system. Adoption of new appliances should be tentative. Limit of amount of precautions.

"Improvements in railway safety appliances will be retarded unless a proper subordination of that which "is mechanically possible to that which is *financially rational* is recognised; and unless the money that is "available for one purpose is spent in the best possible manner."

AMERICAN RAILWAYS.

I visited the Union Switch Company's works at Pittsburg for the purpose of inspecting the various systems of interlocking gear manufactured by this company. American Railways. Union Switch Company, Pittsburg.

One system of working switches which was laid down for inspection was controlled by pneumatically and electrically connecting the switches and signals. The switches were well made, and the connections good Switches worked pneumatically and electrically.

good, the number of levers being one-fifth less than is used in Messrs. Saxby & Farmer's system, for whom Mr. Westinghouse, of the Union Switch Company, is agent in America. The switches are actuated by a pneumatic cylinder, which works the bell-cranks attached to the switches in the usual form, and the small valves controlling the larger valve of the pneumatic cylinder are actuated by electricity. The air-pressure is obtained from a five-horse power steam-engine, pump, and air-vessel. The signals connected with this apparatus, both home and distant, are worked pneumatically by a very simple and ingenious piece of mechanism, the levers actuating three sets of switches, and their respective signals being fixed to a board on a table standing in a room, the board being only 2ft. 6in. long and 18in. wide.

Signals.

ITEM 15.—RAILWAY PERMANENT WAY, JOINTS, AND STEEL SLEEPERS.
ITEM 27.—ARRANGEMENTS FOR MAINTAINING RAILWAY LINES: AVERAGE NUMBER OF MEN TO THE MILE OF SINGLE LINE.

ENGLISH RAILWAYS.

Railway Permanent Way and Joints.

Diagrams in appendix.

In the appendix will be found diagrams representing the permanent way used on various railways in England, India, the Cape, and America. (See Plates Nos. 47 to 52.)

Plate No. 47. Sections of rails.

Plate No. 47, colored blue, shows sections of the rails now in use on twelve of the principal lines in England and on the East Indian and Indian States Railways. The weight of each section of rail per yard lineal is also given on the same sheet.

THE LONDON AND NORTH-WESTERN RAILWAY.

London and North-Western. Rails 84lbs.

The London and North Western Railway uses a bull-headed section of steel rail weighing 84lbs. to the yard, rolled in lengths of 30ft. with deep fishplates weighing 42lbs. per pair; chairs of cast iron, weighing 47½lbs. each, secured with two spikes and two screws through oak ferrules to the sleepers, which are spaced 3ft. apart.

THE GREAT WESTERN RAILWAY.—PLATE No. 47.

Great Western Railway. Main line rails 80lbs. Branch line rails 75lbs.

The Great Western Railway uses, on the main lines, a double-headed section of steel rail, weighing 80lbs. to the yard, and fishplates, weighing about 25lbs. per pair. The chairs weigh 38lbs. each, and are secured by two fang bolts to the sleepers, which are spaced 2ft. 9in. apart. On the branch lines, where the traffic is light, a Vignoles', or flat-bottom rail, is used, weighing 75lbs. to the yard.

THE MIDLAND RAILWAY.—PLATE No. 48.

Midland Railway. Rails 85lbs.

The Midland Railway uses a bull-headed section of steel rail, weighing 85lbs. per lineal yard, with deep fishplates curved under the lower flange, weighing 29lbs. per pair, and bolted with steel bolts and Ibbotson's patent die locknuts, a fastening which is being extensively used by this company. Grover's patent spring washers are also used. The chairs are cast iron, weighing 39lbs. each, secured to the sleepers, which are spaced 2ft. 10½in. apart with two spikes and two trenails.

THE GREAT NORTHERN RAILWAY.—PLATES Nos. 49 and 50.

Great Northern Railway. Rails 80lbs. Rails laid to breakjoint. Ibbotsons's patent fishbolts and die locknuts.

The Great Northern Railway uses a bull-headed section of steel rail weighing 80lbs. to the yard, with fishplates weighing 40lbs. per pair. The chairs are cast iron of the ordinary type, weighing 41lbs. each, and are secured to the sleepers by two trenails and one spike; but joint chairs are also used in conjunction with the fishplates, secured by two spikes and two trenails to the sleepers, which are laid at the rate of 2,263 to the mile. The rails are frequently laid so as to "break joint," and it is affirmed that a much smoother road is obtained by adopting this plan, which is readily done where a joint chair is used. Ibbotson's patent steel fishbolts and dienuts are also used on portions of this railway.

THE LONDON, BRIGHTON, AND SOUTH COAST RAILWAY.—PLATE No. 50.

London, Brighton, and South Coast Railway. Rails 78lbs.

The London, Brighton, and South Coast Railway uses a double-headed section of steel rail weighing 78lbs. to the yard, with fishplates weighing 23lbs. per pair, and cast-iron chairs of the ordinary type, weighing 40lbs. each, secured by three hollow trenails and spikes to the sleepers, which are spaced 2ft. 8in. apart.

THE NORTH-EASTERN RAILWAY.—PLATE No. 51.

North-Eastern Railway. Rails 80lbs.

The North-Eastern Railway uses a double-headed section of steel rail weighing 80lbs. to the yard. The fishplates weigh 26lbs. per pair. Ibbotson's patent steel bolt and dielock nuts are used on this railway. The chairs are cast iron, of the ordinary type, weighing 40lbs. each, secured by two twisted spikes to the sleepers, which are spaced 2ft. 9½in. apart.

THE LONDON AND SOUTH-WESTERN RAILWAY.—PLATE No. 52.

London and South-Western Railway. Rails 82lbs.

The London and South-Western Railway uses a double-headed section of steel rail weighing 82lbs. to the yard, and steel fishplates weighing 23lbs. per pair. The chairs, 40lbs. each, are cast iron, secured with three hollow trenails and spikes to the sleepers, which are spaced 3ft. apart on the average.

THE

THE MANCHESTER, SHEFFIELD, AND LINCOLNSHIRE RAILWAY.—Plate No. 51.

Manchester, Sheffield, and Lincolnshire Railway. Rails 83lbs.

The Manchester, Sheffield, and Lincolnshire Railway uses a double-headed section of steel rail, weighing 83lbs. to the yard, rolled in lengths of 30ft., and ordinary fishplates, weighing 27lbs. per pair. The chairs are of the usual type and weight. The fishbolts are of the ordinary type; but the use of the patent steel fishbolts and die-lock nuts of Ibbotson's is being rapidly extended. The sleepers are spaced 2ft. 8in. apart.

THE NORTH BRITISH RAILWAY.—Plate No. 51.

North British Railway. Rails 75lbs.

The North British Railway uses a double-headed section of steel rail, weighing 75lbs. to the yard, with ordinary fishplates, weighing 20lbs. per pair. The chairs are cast iron of the ordinary type, weighing 34lbs. each, and secured by two iron spikes to the sleepers, which are spaced 2ft. 5in. to 2ft. 8in. apart. Ibbotson's steel bolts and die-lock nuts are used on this railway.

THE METROPOLITAN DISTRICT RAILWAY.—Plate No. 51.

Metropolitan District Railway. Rails 92lbs.

The Metropolitan District Railway uses a bull-headed section of steel rail, weighing 92lbs. to the yard, with deep curved fishplates, weighing 48lbs. per pair. The chairs are cast iron of the ordinary type, weighing 39lbs. each, and secured by two fangbolts to the sleepers, which are spaced 2ft. 8in. apart. Ibbotson's patent steel fishbolts and die-lock nuts are used on some portions of the line, and on others Grover's patent spring washer is used.

THE GREAT EASTERN RAILWAY.—Plate No. 52.

Great Eastern Railway. Rails, 85lbs.

The Great Eastern Railway uses a bull-headed section of steel rail, weighing 85lbs. to the yard, with deep fishplates, weighing 38½lbs. The chairs are of cast iron, about 40lbs. each, secured with two trenails and two spikes to the sleepers, which are spaced 2ft. 2in. to 3ft. apart.

(15) Steel Sleepers.

London and North-Western Railways. Steel chairs and sleepers.

On the London and North-Western Railway steel sleepers and chairs are used in some localities, about ten miles having been already laid. This sleeper and chair were designed by Mr. Webb, the locomotive superintendent at Crewe, and I witnessed the operation of forming the steel chairs, which are manufactured from the scrap ends of the steel rails made at the works.

Plate No. 53.

The chairs and sleepers are illustrated in Plate No. 53, which is reproduced from the original photographs by the proprietors of the *Railroad Gazette*. The chairs, after being stamped by special machinery, are riveted to the sleepers, a piece of tarred pasteboard being placed between the chair and the sleeper, to prevent the tendency of the rivets to become loose from the vibration of the trains.

There have been various systems of steel sleepers and fastenings introduced, and I will describe those which appear to be the best.

P. & W. MacLellan's System.

Messrs. P. & W. MacLellan, of the Clutha ironworks, Glasgow, have introduced several patents in conjunction with Mr. Smith, for the improvement of the permanent way of railways, viz. :—

An elastic embossed sleeper chair, in which strength, elasticity, durability, lightness, moderate first cost, and saving in laying and maintenance are combined, and as each part is forged by machinery the sleepers are exact duplicates of each other, being embossed, punched, and completely finished before leaving the dies.

Plate No. 54.

Plate No. 54, Figure No. 1, shows a perspective view, and Figure No. 3 a cross section, of a railway with a gauge tiebar passing through the sleeper.

Figure No. 2 is a perspective view of a railway having an intermediate gauge tiebar, secured directly to the rails.

Figures Nos. 4 and 5 show horizontal and cross sections of embossed sleepers.

Tests.

These sleepers have been subjected to severe tests, and it has been demonstrated that sleepers made from steel plates one-eighth of an inch in thickness possess ample strength to carry the heaviest rolling-stock.

Cost. 62lbs. rails.

The cost of a mile of sleepers for a railway 3ft. 6in. gauge, and 62lbs. rails, with wrought-iron tiebars, patent steel locknuts and steel bolts and clips—spaced 2ft. 9in. apart—would be about £725, and the weight would be about 52 tons per mile.

50lbs. rails.

For a 50lbs. rail, same gauge as above, but with 2ft. 6in. bearings, the cost would be about £690 per mile, and the weight about 49½ tons per mile.

41lbs. rails.

For a 41lbs. rail of same gauge, with 2ft. 2in. bearings, the cost would be about £708 per mile, and the weight 51 tons per mile.

Prices include packing and shipment.

All the prices quoted above are f.o.b. Glasgow, and include packing and shipment.

Transverse embossed sleeper Plate No. 54.

Messrs. MacLellan & Co. have also introduced an embossed transverse sleeper, illustrated in Plate No. 54. This kind of sleeper is much to be preferred to the one described above, and would be admiraby adapted for the Palmerston and Pine Creek Railway.

These

Palmerston and Pine Creek Railway.

These sleepers are about 6ft. long, and the rails are secured either by two clips and two vertical steel bolts, with locknuts, or by two clips and one horizontal locknut, combined with Sterne's locking washer, which would be preferable; but perhaps the best thing would be to thicken the steel where the rail bears, and to form the outside clip from the solid steel of the sleeper and have only one inside bolt.

Sizes and weights.

The sizes and weights of these sleepers are as follow:—

The 6ft. x 10in. x 3in. sleeper weighs 56¾lbs. each.
" 6ft. 3in. x 10in. x 3in. sleeper weighs 58¾lbs. each.
" 6ft. 6in. x 10in. x 3in. " " 60¾lbs. "
" 6ft. 9in. x 10in. x 3in. " " 62¾lbs. "

Weight per mile.

The weight per mile is from 48 to 55½ tons, and varies according to size and number of sleepers used per mile.

Price f.o.b. Glasgow.

The price f.o.b. Glasgow may be taken at £14 10s. per ton, and the freight out to the colony at about 10s. per ton deadweight.

It has been carefully calculated, on the basis that metal sleepers are known to last at least three times as long as timber, that the renewals of the timber sleepers, with labor and interest added to the cost of each renewal, is equivalent to a deduction of 1½ per cent. per annum from the dividend of a railway company; and as regards the maintenance expenses, it has been demonstrated at the Institution of Civil Engineers of London (session 1881-82) that on the Oude and Rohilkund Railway in India, upon which many hundred miles of embossed steel sleepers $\frac{1}{16}$ of an inch thick have been laid for upwards of six years, the maintenance was in consequence reduced below the cost of any other railway in India. Mr. Batho, the consulting engineer of this railway, states that the embossed steel sleepers laid down during the year 1875 show no signs of corrosion.

Average life of steel and redgum.

From the experience gained in the use of steel and wrought iron for sleepers, the average life of a steel sleeper may be safely taken at thirty-five years, especially if they are coated with Dr. Angus Smith's or some similar composition before being laid down, whereas the average life of redgum sleepers may be taken at fifteen years.

Plate No. 54.

Woods' Patent System.—Plate No. 54.

Woods' system.

When in London I was shown a very good system of steel sleeper and fastening, patented by Mr. Charles Woods, of Middlesborough. It consists of a wrought-iron or steel inverted trough sleeper, 5ft. 6in. long and 8in. wide, by a quarter of an inch thick, fitted with a steel clip and compressed elm keys to hold the rail.

Cost.

The price for sleepers as above, suited for a 3ft. 6in. gauge railway, would be—with open-ends £440 per mile; with ends turned down, £462 per mile; and with ends closed, £506 per mile; one sleeper to every yard being the basis of the above prices. The objection to the use of this kind of road in this colony is the continued trouble caused by shrinkage of the wooden keys, and the liability to their destruction by white ants; but a spiral steel key might be substituted.

(27) Arrangements for Maintenance.

South Italian and Roman Railways.

ITALIAN RAILWAYS.

I have been unable to obtain the requisite information with regard to the Alta Italian Railway, but on the Roman and South Italian Railways the following particulars are available:—

SOUTH ITALIAN RAILWAYS.

Number of men per mile.

Men employed 3,994
On kilometers ..... 1,446 = 2·36 men per kilometer, or 4·34 men per English mile (a kilometer being equal to 0·62 of an English mile)

ROMAN RAILWAYS.

Number of men per mile.

Men employed 3,516
On kilometers ..... 1,593 = 2·1 men per kilometer, or 3·19 men per English mile.

The South and Roman Railways pass through malarial country, and the average number of men is very materially increased for that reason.

English Railways.

ENGLISH RAILWAYS.

THE LONDON, BRIGHTON, AND SOUTH COAST RAILWAY.

The average number of men employed on single lines is 1·37 per mile, and on double lines 2·26 per mile; but at terminal stations, where there are four or more lines of rails, there are as many as eight men to the mile engaged on the maintenance. The lines are divided into districts of about thirty miles each, with an inspector in charge of each district.

Number of men per mile.

THE LONDON AND SOUTH-WESTERN RAILWAY.

London and South-Western Railway.

The number of men employed, as a rule, on this railway, is 1 ganger and 3 men for every two or three miles of double line; but at junctions, and about the neighborhood of London, greater strength is required.

THE GREAT WESTERN RAILWAY.

Great Western Railway.

The number of men engaged in maintaining this system is—for main lines with four lines of rails, 3½ men per mile of single line of mixed gauge, and for branch and light traffic lines of the system, 2 men per mile of single line.

THE LONDON AND NORTH-WESTERN RAILWAY.

London and North-Western Railway.

The number of men employed in maintaining this railway varies from 10·36 per mile of single line in London and neighborhood where there are four lines of rails, to 4·25 men per mile of single line in the country, where there are only two lines of rails.

THE MIDLAND RAILWAY.

Midland Railway.

The ordinary maintenance gang is composed of 5 men, including a ganger, to whom is allotted lengths varying from two and a half miles of double line, including small stations, to half a mile of double line, including large stations. For main line work, the average number of men is 5 to every two miles of double line. Taking the whole of the Midland Company's lines, the average number of men employed on maintenance of way is 1 man for every mile of single line; and it is asserted that single lines require a greater number of men per mile than double lines, on account of the greater distance that the men have to walk. Where the traffic is 150 trains in twenty-four hours, a gang of 5 men repair two miles of double line exclusive of stations.

Single lines more expensive to maintain per mile than double lines.

THE MANCHESTER, SHEFFIELD, AND LINCOLNSHIRE RAILWAY.

The ordinary maintenance gang is composed of 4 men, including a ganger, who keep in repair two and a quarter miles of double line, including stations. In some districts a gang of 5 men keep in repair half a mile of double line and a large station. The usual plan is to allot two miles of double line, with a traffic of 120 trains in twenty-four hours, excluding large stations, to a gang of 4 men, including a ganger

Manchester, Sheffield, and Lincolnshire Railway.

THE GREAT NORTHERN RAILWAY.

The average number of men employed on the Great Northern system is 1 man to every mile of single line.

Great Northern Railway.

GENERAL OBSERVATIONS.

The average number of men engaged on the maintenance of way only on the principal railways is 1 man to every mile of single line. The relaying gangs generally consist of 20 men to every fifty miles of double line.

Average number of men on permanent way.

The difference in the maintenance charges on English lines is to some extent due to the fact that, on many of the railways, capital account is charged with some portion of the outlay, such as the increased cost of a heavier rail; but on the Midland Railway, for example, all the outlay for maintaining existing permanent way is charged to maintenance account.

Maintenance charges.

I herewith append a statement showing the cost per mile of railway, and per mile of single line per annum, during the years 1875 and 1882, under the head of "Maintenance and Renewal of Permanent Way," of some of the principal railways in England.

Relaying gang.

Plate No. 52A illustrates the permanent way on the Tilbury and South End, the Great Western, the Furness, and the Natal Government railways.

Plate No. 52A.

Plate No. 52B illustrates the permanent way on five of the principal railways in Ireland.

Plate No. 52B.

COST per MILE of RAILWAY and per MILE of SINGLE LINE per annum during the Years 1875 and 1882, of the various items included under the head of MAINTENANCE and RENEWAL of PERMANENT WAY of the following Railways.

Name of Railway.	Half-year ending.	Miles of Railway.	Equivalent in Miles of Single Line.	Staff and Office Charges.		Wages.		Materials.		Total.	
				Per Mile of Railway.	Per Mile of Single Line.	Per Mile of Railway.	Per Mile of Single Line.	Per Mile of Railway.	Per Mile of Single Line.	Per Mile of Railway.	Per Mile of Single Line.
				£ dec.	£ dec.	£ dec.	£ dec.	£ dec.	£ dec.	£ dec.	£ dec.
1. Midland Railway	June 30th 1875	1,104¼	2,008½	17·12	9·41	175·27	96·36	225·35	123·90	417·74	229·67
	June 30th 1882	1,392	2,555¼	14·88	8·10	138·54	75·36	84·69	46·12	238·11	129·58
	December 31st 1875	1,106½	2,025½	14·80	8·09	186·64	101·99	228·82	125·04	430·26	235·12
	December 31st 1882	1,392½	2,559⅝	15·49	8·43	147·40	80·20	117·78	64·08	280·67	152·71
2. Lancashire and Yorkshire Railway	June 30th 1875	397¾	773½	14·74	7·58	164·73	84·73	125·71	64·66	305·18	156·98
	June 30th 1882	493	965¼	20·06	10·24	144·90	74·00	101·42	51·80	266·38	136·04
	December 31st 1875	437¼	851	13·70	7·04	158·75	81·57	458·34	235·50	630·79	324·10
	December 31st 1882	493	965¼	18·32	9·36	147·29	75·23	167·74	85·67	333·35	170·26
3. London, Brighton, and South Coast Railway	June 30th 1875	347½	628¾	6·65	3·68	125·54	69·38	132·11	73·01	264·30	146·07
	June 30th 1882	382¼	657¼	9·68	5·65	138·57	80·54	119·08	69·22	267·33	155·41
	December 31st 1875	347½	630½	6·67	3·68	123·77	68·22	106·87	58·90	237·31	130·80
	December 31st 1882	390	673	9·20	5·32	132·36	76·70	111·50	64·62	253·06	146·64
4. London and South-Western Railway	June 30th 1875	665½	1,094¾	5·25	3·20	*—	—	—	—	259·85	157·96
	June 30th 1882	707½	1,205$\frac{3}{16}$	7·30	4·28	148·23	87·04	139·17	81·72	294·70	173·04
	December 31st 1875	674¾	1,104	5·03	3·08	*—	—	—	—	312·33	190·90
	December 31st 1882	707½	1,205$\frac{3}{16}$	6·98	4·06	147·25	86·46	169·38	99·46	323·61	190·02
5. North-Eastern Railway	June 30th 1875	1,400½	2,304	11·52	7·00	127·22	77·32	141·62	73·92	260·36	158·26
	June 30th 1882	1,496½	2,486½	11·00	6·63	114·88	69·15	55·13	33·18	181·01	108·96
	December 31st 1875	1,400½	2,304	12·16	7·38	154·64	94·00	268·40	163·14	435·20	264·54
	December 31st 1882	1,502½	2,490¼	11·32	6·83	135·87	81·96	162·61	98·08	309·80	186·88
6. London and North-Western Railway ..	December 31st 1875	1,564¼	2,828½	18·79	10·38	173·83	96·14	376·83	208·42	569·45	314·94
	December 31st 1882	1,667½	2,976½	22·33	12·51	158·90	89·02	162·58	91·08	343·81	192·61
7. Manchester, Sheffield, and Lincolnshire Railway	December 31st 1875	259½	516¾	14·54	7·30	124·84	62·69	186·29	93·55	325·67	163·54
	December 31st 1882	300½	609⅜	13·41	6·62	110·32	54·44	105·40	52·01	229·13	113·07

* Wages and materials not given separately in report.

AMERICAN RAILWAYS.

Permanent Ways and Joints.

As the Pennsylvania Railway is the acknowledged standard of the best American practice, I have taken it as an example. The standard sections of rail used on the Pennsylvania Railway, together with the fishplates, sleepers, and cross section of formation and ballast adopted by this railway company in 1878, are illustrated in Plate No. 8. Pennsylvania Railway. Plate No. 8.

The rails used are of the "Vignolles" or flat-footed section of steel, rolled in lengths of 30ft., and weigh respectively 60lbs. and 67lbs. to the yard. The fishplates are of steel, weighing about 36lbs. per pair for the 67lb. rails, and are flanged down to cover the foot of the rail, and form a bracket upon the sleeper, to which they are dog-spiked. The fishbolts are of iron, made oval under the head to fit the hole in the fishplate, and are used with the "Verona" spring washer under the nut. This fastening has a good reputation in the States. The sleepers are 8ft. 6in. long by 8in. wide by 7in. thick, and are laid upon 12in. of broken stone or gravel. Where stone is used it is shouldered up to the level of the top of the sleepers, but in the case of gravel it is formed with slopes for drainage. Rails, 60lbs. and 67lbs. per yard. Sleepers. Ballast.

When at Messrs. Crerar & Adams's railway supply stores, in Chicago, I saw a very ingenious nutlock for fishplate bolts, called the "Mercer Nutlock." It is a very good nut fastening, and from the trials given upon various lines it is stated that the nuts never altered from their original positions, and no nut could be forced up one-quarter of a turn with a wrench. This fastener, which is illustrated on Plate No. 54, is made of malleable cast iron, and the nuts are automatically locked at every quarter turn. The price of these locks is £10 per thousand. "Mercer" nutlock. Plate No. 54.

Various descriptions of nutlocks for fishplate bolts have been patented and tried, but I have not heard, in the course of my travels, of any nutlock that surpasses that patented by Mr. Alfred Ibbotson, which consists of a dienut cut with a differential thread, the bolt being made from mild steel, and the dienut of steel with a harder temper. The act of screwing up the nut—which requires some considerable force—cuts a thread upon the end of the bolt of a smaller diameter than the original thread, but of the same pitch, thus bringing the bolt and nut into actual metallic contact. Another nut patented by Mr. Ibbotson is also made of steel, and is cut with a differential thread; but instead of cutting its thread upon the bolt, as in the former case, slits are sawn across the nut for nearly one-half of its depth, and these slits allow the nut to expand when being screwed upon the bolt as soon as it reaches the smaller diameter thread, thereby making absolute contact; and should the frequent removal of the nut make it loose on the bolt, the threads can be made a tight fit again by simply closing up the slits slightly with a few blows from a hammer. Nutlocks. Ibbotson's nutlock.

The die locknut has been extensively used on the South Australian Railways for the last few years with marked success, and it is rapidly coming into use on the principal railways of the United Kingdom, where several miles have been laid down with these fastenings.

I append a specification used by the Pennsylvania Railroad Company for a perfect sub-division of their line.

Pennsylvania Railroad.—Specifications for a Perfect Subdivision.

"1. *Line.*—The track must be in true line.

"2. *Surface.*—The track must be in good surface; on straight lines the rails must be on the same "level, and on curves the proper elevation must be given to the outer rail and carried uniformly around "the curve. This elevation should be commenced from 50ft. to 200ft. back of the point of curvature, "depending on the degree of the curve, and increased uniformly to the latter point, where the full elevation "is attained. The same method should be adopted in leaving the curve.

"3. *Joints.*—The joints of the rails must be exactly midway between the joint ties, and the joint on one "line of rails must be opposite the centre of the rail on the other line of the same track. In winter a dis"tance of five-sixteenths of an inch, and in summer one-sixteenth of an inch, must be left between the ends "of the rails, to allow for expansion. The splices must be properly put on with the full number of bolts, "nuts, and nutlocks, and the nuts screwed up tight. The rails must be spiked both on the inside and out"side on each tie, on straight lines as well as on curves, and the spikes driven in such position as to keep the "ties at right angles to the rails.

"4. *Ballast.*—There must be a uniform depth of at least twelve inches of clean, broken stone or gravel "under the ties. The ballast must be filled up evenly between but not above the top of the ties, and also "between the main tracks and sidings where stone ballast is used. In filling up between the tracks, coarse, "large stones must be placed in the bottom in order to provide for drainage; but care should be taken to "keep the coarse stone away from the ends of the ties. At the outer ends of the ties the ballast must be "sloped off evenly to the sub-grade. When stone is used it must be broken evenly, and not larger than a "cube that will pass through a two-and-one-half-inch ring.

"5. *Cross-ties.*—The cross-ties must be properly and evenly spaced, with 10in. between the edges of "bearing surfaces at joints, with intermediate ties evenly spaced, and the ends on the outside on double "track, and on the right-hand side going north or west on single track, lined up parallel with the rails. The "ties must not be notched under any circumstances, but should they be twisted must be made true with the "adze, that the rails may have an even bearing over the whole breadth of the tie. For main running tracks, "sixteen ties; for branch roads and third tracks on main lines used exclusively for freight trains, fourteen "ties;

" ties; and for sidings and tracks used for standing cars only, not exceeding twelve ties are to be used for " each thirty-foot rail. Supervisors and track-foremen will be held strictly accountable for any deviation " from these specifications.

" 6. *Switches.*—The switches and frogs must be kept well lined up and in good order. Switches must " work easily, and safety blocks attached to every switch head where " stub" switches are used. Switch " signals must be kept bright and in good order, and the high signal used for all switches where trains run " against the points. Particular attention must be given to avoid low joints at the head blocks of switches. " The standard distance between guard rail and main rail at frogs will be 2in.

" 7. *Sidings.*—All company sidings should be kept in as good order as practicable, using for this " purpose second-class rails and ties, or the partly worn material taken from main tracks. Owners of private " sidings must be required to keep their sidings in safe condition for use at all times.

" 8. *Ditches.*—The cross-section of ditches at the highest point must be of the width and depth as " shown on the standard drawing, and graded parallel with the track, so as to pass water freely during heavy " rains and thoroughly drain the road-bed. The line of the bottom of the ditch must be made parallel with " the rails, and well and neatly defined, at a distance of not less than 7ft. from the outside rail. All neces- " sary cross-drains must be put in at proper intervals. Earth taken from ditches or elsewhere must be " dumped over the banks, and not left at or near the ends of the ties, but distributed over the slope. Earth " taken out of the ditches in cuts must not be thrown on the slope. The channels or streams for a consider- " able distance above the road should be examined, and brush, drift, and other obstructions removed. " Ditches, culverts, and box drains should be cleared of all obstructions, and the outlets and inlets of the " same kept open to allow a free flow of water at all times.

" 9. *Road Crossings.*—The road-crossing planks must be securely spiked; the planking should be " three-quarters of an inch below the top of rail, and two and one-half inches from the gauge-line. The ends " and inside edges of planks should be beveled off.

" 10. *Station Grounds.*—Station platforms, fences, and grounds at stations must be kept clean and in " good order.

" 11. *Policing.*—The telegraph poles must be kept in proper position, and trees near the telegraph line " must be kept trimmed to prevent the branches touching the wires during high winds. All old material, " such as old ties, old rails, chairs, car material, &c., must be gathered up at least once a week and neatly " piled at proper points. Briers and undergrowth on the right-of-way must be kept cut close to the ground.

" 12. *Use of Materials.*—Proper judgment and caution must be exercised by engineers, supervisors, " and foremen against extravagant use of materials, as they will be held strictly responsible for the same.

" By order of General Manager,

" WM. H. BROWN, Chief Engineer.

" Office of Chief Engineer Pennsylvania Railroad Company, Philadelphia, June 1st, 1882."

Cost of maintaining railways South Australia, 1882-3.

Maintenance of Permanent Way and Works on the South Australian Railways.

The following statement is prepared to illustrate the cost of maintaining the road and real estate of the railways in South Australia on both gauges for the year ending June, 1883:—

Broad Gauge System, 5ft. 3in., 231½ miles.

Statement of cost of maintenance per average mile open, year ending June 30th, 1883.

	North and Port Lines.
Average number of miles open	231½ miles.
	£ s. d.
Superintendence and office expenses	8 14 5
Maintenance of way—	
Wages	92 12 7
Materials	7 7 8
Engine-power	0 8 0
Maintenance of works and buildings—	
Wages	22 4 9
Materials	9 14 1
Ways and works accidents	0 2 7
Total ordinary maintenance	£141 4 1
Reconstruction of way	65 13 4
Grand total	£206 16 5

The number of men employed per mile of average length of miles open is as follows:—

Maintenance of permanent way—	
Ganger and packer	·81
Maintenance of works and buildings—	
Artisans and laborers	·17
Total for way and works	·98

Narrow

Narrow Gauge System, 3ft. 6in., 671½ miles.

Statement of cost of maintenance per average mile open, year ending June 30th, 1883.

	Hamley, Wakefield, Wallaroo, and Snowtown Lines.	Port Pirie, Terowie, and Quorn Lines.	Great Northern Lines.	Kingston and Tatiara, Rivoli Bay and Mount Gambier Lines.	Average Narrow Gauge Lines.
Average number of miles open	157¼ miles.	168½ miles.	198¼ miles.	147¾ miles.	671½ miles.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Superintendence and office expenses	9 1 9	5 10 7	7 9 2	7 5 4	7 6 3
Maintenance of way—					
Wages	51 2 5	47 13 10	68 14 2	61 18 9	59 0 8
Materials	1 1 6	2 10 5	2 4 9	3 0 7	2 4 2
Engine-power	—	0 14 6	0 19 8	0 12 7	0 12 2
Maintenance of works and buildings—					
Wages	3 0 7	2 18 3	3 6 8	1 10 8	2 15 3
Materials	1 15 6	1 9 4	2 16 4	1 14 10	2 0 0
Way and works accidents	0 4 8	—	5 3 4	—	1 11 7
Total ordinary maintenance	66 6 5	60 16 11	90 14 1	76 2 9	75 10 1
Reconstruction of way	—	—	—	—	—
Grand total	66 6 5	60 16 11	90 14 1	76 2 9	75 10 1

The number of men employed per mile of average length of miles open is as follows:—

Maintenance of permanent way—					
Gangers and packers	0·49	0·63	0·57	0·60	0·57
Maintenance of works and buildings—					
Artisans and laborers	0·05	0·02	0·05	0·03	0·04
Total for way and works	0·54	0·65	0·62	0·63	0·61

Item No. 16.—RAILWAY STATION LUGGAGE LIFTS, TRAVERSERS, &c.

Accidents attributable to defective construction.

The question of safety to passengers using lifts for domestic or business purposes is a very important one, and the majority of accidents that have occurred in Europe and America have been generally attributable to inherent defects in the construction of the machinery employed. Notwithstanding that lifts worked by wire ropes actuated by steam or hydraulic power are more extensively used in America than direct-acting hydraulic lifts, it is a matter for serious consideration whether the systems in ordinary use embody all the requirements necessary to ensure absolute safety to life and limb. There can be very little doubt that a cage supported from below and directly actuated by an hydraulic ram (provided of course that the connections are sound and well made) is much safer than a cage suspended by wire ropes wound round actuating drums, and balanced by chains and counter-weights; and therefore any device by which danger caused by breakage of the actuating ropes or the chains of the balance weights can be eliminated is certainly a step in the right direction. Contrivances for this purpose have been produced in England and America, and will be described below.

Traversers.

Hydraulic traversers.

Hydraulic traversers are not much used in England or America. A steam engine actuating wire ropes, or the engine itself directly attached to the traverser is preferred.

Steam traversers

At the Grand Central Station, New York, there is a very large traverser, used for traversing bogie carriages, fitted with a steam engine and wire ropes. And at Pullman's shops the traversers used for the same purpose are actuated by a motor, which is used for drawing the carriages out of the shops on to the traverser and moving them where required.

The engines at the New York Central Railway Station are of the vertical type, capable of developing about 20 h.p., and are placed at one end of the traverser pit. The engines drive gearing to which is attached pulleys, 3ft. 6in. in diameter, for carrying the wire rope. These pulleys have blocks of indiarubber let into the groove round their circumferance, the rubber being dipped into hot water immediately before being pressed into the groove in the casting, and the pressure of the wire rope always keeps the rubber in place until it is worn out, which in this case takes from three to four months. The traverser is stopped and started by sliding a tightening pulley outwards or inwards, thus slackening or tightening the wire rope.

Lifts in England and on the Continent.

Direct acting hydraulic lifts used in England and on the Continent.

In England and on the Continent of Europe the hydraulic lifts used in many of the public buildings, hotels, and places of business, are generally made direct acting, *i.e.*, the lift is actuated by a ram directly attached

attached to the bottom of the cage, the length of the ram being governed by the height of the lift. These direct-acting lifts are generally worked by the town water pressure, and are balanced by weights carried by chains attached to the cage; but these machines are usually very slow in their action, and are not always as safe as is generally supposed, the late serious accident at the Grand Hotel, Paris, having been caused by the breakage of the connection between the cage and the ram, resulting in the cage being suddenly carried up by the chains and counter-weights to the top of the building, when these chains broke, and the cage, with its occupants, was precipitated down the lift well.

Accident Grand Hotel, Paris.

Sir Wm. Armstrong's Lifts.

Sir Wm. Armstrong's works.

When in England I visited the works of Sir Wm. Armstrong, at Newcastle-upon-Tyne, for the purpose of obtaining information upon the various forms of hydraulic lifts, traversers, cranes, &c., used in connection with railway and dock traffic, and through the courtesy of the London manager, Mr. Shapton, I was shown the machinery at the principal railway stations and docks in London, where the hydraulic lifts in use were made upon the usual principle of a cylinder and ram acting upon a chain, with the intervention of multiplying sheaves to extend the range of the lift. I also inspected the various appliances for loading and discharging coal and grain, which I propose to describe more particularly under item No. 20.

Machinery used at English Railway stations.

Loading coal and grain (see Item No. 20).

Waterloo Station lifts for milk traffic.

Safety springs.

Guard round lifts and self-acting gate.

At the Waterloo Station, London, there are twelve hydraulic lifts on the platform, made by Sir Wm. Armstrong & Co., used for parcel and milk traffic, worked very rapidly by hydraulic rams fixed horizontally, and fitted with the ordinary head and chains by which the cage is hoisted. Each cage is provided with a coiled spring, which uncoils should the chains break, and presses four rollers against the upright guides, holding the cage securely, and preventing its sudden descent. On the station platform the lift wells are surrounded on three sides with a light iron guard, and a contrivance is worked by the lift or cage platform by which it is impossible for any accident to occur to any person by falling down the opening after the lift has descended below the platform level. This device consists of two vertical iron bars, to which is attached a light iron gate. These bars and the gate slide vertically together upon the two uprights forming the guard round the lift opening; the two vertical bars to which the sliding gate is attached pass through the floor of the station platform, and allow the bottom of the gate to rest on it when the lift is down; and as it again rises, the two bars carrying the gate come into contact with the platform of the lift or cage, and carry the gate up until the lift reaches the station platform level.

Mr. Ellington's Lifts.

Ellington's balance lifts.

Mr. E. B. Ellington, of London, has perfected the hydraulic lift, and in his balance lifts has succeeded in reducing the risk to life and limb to a minimum. By this contrivance he has increased the speed of the lift, and all risks from breaking of chains or rams are avoided. He has recently erected one of these machines at the Palace Chambers, Westminster, and the working of it has been most satisfactory. By this arrangement a sufficient pressure of water can be obtained in the lifting cylinder, independently of the available pressure for working the lift, to render the use of counter-weights and chains unnecessary.

Hydraulic balance.

The hydraulic balance consists of a short ram working in a cylinder placed close to the lifting cylinder, but the rams of these two cylinders are so arranged as to work at the same time in opposite directions.

It is claimed by the patentee—

Advantages claimed.

That the following advantages are gained by this plan of balance lift:—

1st. That it possesses the greatest possible safety:

2nd. That it possesses a high speed in working:

3rd. That there is a reduced consumption of water:

4th. That there is diminished wear and tear:

5th. That it is adapted to varying pressures of water:

6th. That all the mechanism is below the cage, the weight being taken from the foundations.

Plate No. 55.

These lifts are illustrated in Plate No. 55.

Figure I.

Figure I. is an ordinary form of lift, with its cylinder, ram, and cage, but the ram is smaller than usual, because its strength depends upon the load required to be lifted, and not by the pressure of the water available. A is the hydraulic cylinder attached to the cage. B is another hydraulic cylinder connected with A, and with a third cylinder C placed below it, the pistons in B and C being connected by the piston rod. The annular area of the lower piston is sufficient when actuated by the water pressure to overcome all friction, and lift the "net" load whole the full area of the upper piston, when actuated by the water pressure and balances the weight of the ram and cage. The working is controlled by a single valve connected to a hand-rope, chain, or lever. An interlocking apparatus is also attached to lifts used for domestic purposes, by means of which the opening of the doors of the lift-well is prevented except at the time when the cage is at rest, and is level with the door to be opened.

Interlocking gear.

Figures 2 to 10.

Figure 2 represents a passenger lift fitted in a spiral staircase; and figure 3 a large passenger lift suitable for public buildings.

Figure 4 represents a passenger lift with the balance fitted horizontally in order to economise space.

Figures 5 and 6 illustrate the mode of applying the water pressure by steam or gas engines when the town supply is not available.

Figure

Figure 7 shows a detail of balance cylinder.

Figure 8 illustrates Ellithorpe's safety arrangement for cages suspended by wire ropes.

Figures 9 and 10 show plan and section of safety brake for direct-acting lifts.

Air chamber. Figure 8.

Referring to figure 8, it will be seen that the lift well is continued below the level of the floor line—forming an air chamber—to the extent of about one-twelfth of the height of the lift. It is contracted towards the bottom, and the lower part of the cage has rubber secured round the edge in order to make a joint with the sides of the well casing. Should the rope break and the cage fall, it would be received in this chamber upon a cushion of air which cannot easily escape, owing to the rubber packing round the bottom. This plan is very extensively used in America for elevators in hotels and public buildings, the only need for caution being in the construction of a thoroughly substantial lining to the portion of the well continued below the floor level, in order to provide against rupture under the pressure of air when the cage first descends.

Extensively used in America.

Figures 9 and 10. Automatic hydraulic brake.

Figures Nos. 9 and 10 illustrate an automatic hydraulic brake, the action of which is as follows:—The lift ram R is embraced by two brake blocks AA, which, by a system of toggle levers, are connected with the piston rod B of the piston C working in a small hydraulic cylinder. The back end of the piston at D communicates with the water pressure, and the front end at E with the lift cylinder. If the lift cylinder should burst, and the water escape with velocity sufficient to reduce the pressure within it so far that the lift descends quicker than the nominal speed, the excess pressure in the back of the piston D (not connected with the lift cylinder) causes the piston to move forward in the brake cylinder, and by means of the toggle slips the ram and stops the descent of the cage. The brake can be controlled by hand from the cage, and can be used for holding it in any desired position.

American Lifts or Elevators.

Best makers.

I examined the best description of elevators made in Boston, New York, Philadelphia, and Chicago, and frequently used them in the hotels and public buildings. The best known makers of elevators in the States are:—

Messrs. Whittier, of Tremont-street, Boston;
" Otis Brothers, of Liberty-street, New York;
" Stokes & Parish, of Chesnut-street, Philadelphia; and
" W. E. Hale & Co., of State-street, Chicago.

Whittier's Elevators.

Whittier. Plate No. 56.

The Messrs. Whittier make high-speed, steam, hydraulic, and belt elevators. Their freight hydraulic elevator (Plate No. 56) consists of a single acting hydraulic engine, which makes one stroke while the cage is rising to its full height. The cylinder is fixed either upright or horizontal, and is made of cast iron. Fixed brackets are attached, which carry cast-iron sheaves, fitted with self-oiling brass brushes running upon a steel shaft. These sheaves are connected by the hoisting rope with similar sheaves carried by the crosshead. The piston, of cast iron, is provided with a follower, which secures an improved heavy metallic packing, and has a stroke equal to one-tenth the rise of the cage, whereby the delay and expense of repacking is proportionately smaller than with a piston whose stroke is nearly equal to the height of the well. The piston is attached to the crosshead by two piston rods.

Cylinder.

Sheaves and rope.

Piston.

Two piston rods.

Rope cannot leave sheaves when cage is obstructed.

Shipping rope.

Piston 20in. to lift 1,000lbs.

Two hoisting ropes.

In the upright machine the piston, crosshead, sheaves, and other moving parts are counterbalanced by weights to render the consumption of water as low as possible, and prevent the rope from leaving the sheaves should the cage in its descent be obstructed. The horizontal machine is equally economical in the use of water. The water is admitted to and discharged from the cylinder by an improved balanced double valve, operated directly by the shipping rope, which is arranged in such a manner as to stop the cage automatically at the top and bottom landings. This machine is also fitted with automatic stops, which operate should the rope become deranged. It has a piston of 20in. diameter, and, with a pressure of 55lbs. to the square inch, will lift 1,000lbs. Each elevator is furnished with two hoisting ropes, two counterbalance-ropes, and a shipping rope, all of iron wire.

The crosshead is double and lined with plate iron. The cage, which is 6ft. square, is one of the regular standard freight platforms fitted with Baldwin Merrick's safety apparatus. The guides are wrought iron, with planed faces and edges and dowelled joints.

The price, f.o.b. Boston, for the 20-inch cylinder machine is $990 = £206 5s.; and for other sizes as under:—

For a 30in. cylinder, load 2,000lbs.	$1,140	= £237 10 0
" 36in. " " 3,000lbs.	$1,270	= £264 11 8
" 42in. " " 4,000lbs.	$1,420	= £295 16 8

Add for each 10ft. rise of lift:—

For a 20in. cylinder	$60	= £ 12 10 0
" 30in. "	$70	= £ 14 11 8
" 36in. "	$80	= £ 16 13 4
" 42in. "	$90	= £ 18 15 0

The

Hinkle's patent. Discharge-tank. Pressure-tank. Pump. No water wasted. Cost.

The Messrs. Whittier also supply an apparatus for operating hydraulic elevators under Hinkle's patent system, which consists of a discharge-tank, pump, and pressure-tank. The water exhausted from the elevator passes into the discharge-tank, whence it is forced by the pump into the pressure-tank ready for use again in the elevator cylinder. The pressure-tank serves the purpose of a large air chamber, in which is maintained a constant pressure, usually about 80lbs. to the square inch—though for heavy lifts a constant pressure of 200lbs. to the square inch is often carried. The pump is arranged to start automatically when this pressure is reduced by the starting of the elevator, and stops automatically when the normal pressure is again reached. The water is not wasted, the only running expense being the power required to work the pump. Any number of machines can be worked from one pressure-tank. This description of machine, with a Workington's duplex steam pump, and all the necessary extras and fittings between the hoisting-machine and the pump, would be f.o.b. Boston from $500 to $1,500, or between £104 3s. 4d. and £312 10s., according to the size of cylinder and speed of the elevator required.

Single and double hoisting-machines. Single screw machine. Screw. Automatic brake and stop. Automatic shipper. Two hoisting ropes. Cost.

The same firm make a speciality of their single and double screw hoisting machines for freight purposes. The single screw (size No. 2) is capable of lifting 2,000lbs. at a time. This machine consists of a cast-iron bed, with pockets to hold oil, in which the screw runs, and is therefore always lubricated. The driving-shaft and screw are made from a solid steel forging. The screw-wheel is made of bronze, and the drum of cast iron, grooved in the lathe, to receive the two hoisting ropes. There is an automatic brake, to render the change of motion prompt, and to hold the machine firmly when at rest. There is also an automatic device to stop the elevator if the cage in its descent meets with an obstacle—this device being specially designed to prevent injuries to the machine and its load, which frequently happens when machines have no such device. An automatic shipper to stop the elevator at the top and bottom landings is also supplied. This description of machine, with sheaves overhead for carrying the ropes, two hoisting-ropes, two counter-balance ropes, and one shipper rope of iron wire, together with the cage, 6ft. square, of sound ash, well ironed, and fitted with Baldwin Merrick safety apparatus, the cage having a lift of 50ft. would cost f.o.b Boston—

No. 2.	For a No. 2 size	$520 =	£108	6	8
No. 3.	" 3 machine	$540 =	£112	10	0
No. 5.	" 5 machine, to lift 4,000lbs.	$679 =	£141	9	2

Difference in price for each 10ft. rise—

	For a No. 2 or 3 machine	$16 =	£ 2	6	8
	" 5 machine	$18 =	£ 3	15	0

Double screw machines. Cost.

The double screw machines lift from 4,000lbs to 8,000lbs. each, according to size, and are supplied at the following rates:—

No. 10.	A No. 10 double screw machine	$760 =	£158	6	8
No. 6.	" 6 double screw machine	$1,120 =	£233	6	8

Difference in price for each 10ft. rise—

	For No. 10 machine, or No. 6 machine, each	$18 =	£3	15	0

Direct acting steam screw hoists.

The Messrs. Whittier make another hoisting machine, in which a pair of 8in. x 10in. reversible steam engines are attached directly to the double-screw hoisting machine. The engines are fitted with balance reversing valves, whereby the attendant has perfect control of the machine.

Baldwin safety appliance. Description. **Plate No. 56.**

The Baldwin safety apparatus is illustrated on Plate No. 56, and is applied to all the above machines. A is one of the two cage guides fixed in the well, and extending the whole height of the lift; B represents one of two safety blocks, made of cast steel, attached to the bottom of the cage; F is a corrugated hardened steel roller; G is a lever supporting the roll F; and H is a rod attached to the lever G.

Instantaneous.

In operation the rod H raises the end of the lever G until the roller F within the tapering slot in the safety block is wedged between the guide A, into which its corrugations indent, and the side of the slot, thus holding the cage and its load securely and firmly. It is instantaneous in its action, and the heavier the load the firmer the hold.

Safety hatch for warehouses. **Plate No. 56.** Security against spread of fire.

I was shown in Boston a very ingenious contrivance of safety hatch for elevator wells, which is fully illustrated and described on Plate No. 56. It not only serves as a preventive against accidents to persons by falling down the elevator well, but it also affords a great security against the spread of fire, which would otherwise be seriously augmented by the draught up the open flues formed by the elevator shafts.

Otis and Hale machines.

As the machines made by Otis Bros. of New York, and Hale & Co. of Chicago, are almost identical, I will first illustrate the vertical and horizontal cylinder hydraulic passenger elevator, made by Messrs. Stokes & Parish of Philadelphia, where I saw several at work. The Plate No. 57 shows in detail the principle of both elevators, the only specialty to be noticed being a safety airbrake attached to the bottom of the cage. The work turned out by this firm is very good, and every lift has two hoisting, two counter-weights, and one shipper wire rope or rod. I was unable to obtain any prices from this firm.

Stokes & Parish machine. **Plate No. 57.**

Board appointed by Government to decide upon best elevator.

I may mention that before any elevators were fitted to the public buildings in Chicago and elsewhere, tenders were called for proposals for the passenger and mail elevators required in the new Custom House buildings in Chicago. A Board, consisting of experts appointed by the Acting Secretary of the Treasury, examined and reported on the merits of the plans, specifications, and proposals submitted. The Board proceeded to Baltimore and New York, and personally examined the various elevators in those cities, and as a result

result of their examination the Board recommended the acceptance of the tender of Messrs. Hale & Co., of Chicago, for the machines required.

The Board were unanimously of opinion that elevators using hydrostatic pressure as a motive power are, all things considered, the most satisfactory; and they give the following reasons:— Opinion of the Board of Experts and the reasons.

"Extreme simplicity, minimum amount of machinery, absence of entirely rotating parts, except the "sheaves over which the ropes run, dispensing entirely with high pressure steam." Simplicity.

The machine recommended by the Board has also the following merits:—

"Safety, as there are no cogs, racks, belts, or shafts liable to fracture. Safety.

"The power is applied by a direct downward pull in a straight line, and always in an opposite direction "to the movement of the cage. Applications of power.

"The unwinding of the rope off the drums during a temporary obstruction in the descent of the cage "cannot possibly occur in the Hale machine, as the piston in the hydraulic cylinder is in such cases held in "position by a solid column of water above and between it; consequently the ropes are kept perfectly tight "under strain, and no motion of the cage can take place until the obstruction is removed. Unwinding of rope impossible during obstruction in descent.

"No water can escape when the valve is set to allow the cage to descend; the cage therefore is held, "and when allowed to move can only descend as fast as the water can pass through the pipes and valves. Cage securely held.

"If the shipper rope breaks or becomes detached so that the valves cannot be closed by the attendant, "the piston can only descend to the lower part of the cylinder, raising the cage to the top of the lift, where "it will be held safely until the rope is readjusted. If shipping rope breaks.

"Water ram, or concussion caused by stopping too suddenly, is avoided by a relief valve between the "cylinder and the supply pipe. Water ram.

"No water is used in the descent of the load. In the "Hale" machine, with an ordinary lift, the speed "of the cage is only twice, or at the most thrice, that of the piston, while in other hydraulic machines it is "from ten to twelve times, thus largely increasing the power required to do the work, multiplying the "sheaves and increasing the wear on the ropes. The small size of the cylinder used reduces the friction to "a minimum. No water used in descent of cage.

"The Board conclude by stating that as they believe the Government desire the best machinery, and "that no expense should be spared to ensure the safety and comfort of the individuals who will use the "elevators, they confidently recommend the acceptance of W. E. Hale & Co.'s machines for adoption." No expense should be spared to ensure safety.

The result of this report was that Messrs. Hale & Co.'s elevators are fitted in the State buildings in Chicago. And as the Otis machines, made in New York, are practically the same, it may be safely assumed that the "Standard Hydraulic Elevators" of these two firms are the best machines made in the States, which will sufficiently account for the fact that by far the greater number in use in America are made by Messrs. Hale and Otis Bros. Best machines.

Illustrations of both machines are given on Plate No. 57.

ITEMS NOS. 17 & 18.—

(17).—RAILWAY BRIDGES GENERALLY, SWING AND PONTOON:

(18).—RAILWAY BRIDGES (AMERICAN) AS APPLIED TO THE RIVER MURRAY.

During my tour through England and America I visited most of the principal bridge works, and was most courteously furnished by the proprietors with every information I required, and with illustrated examples of some of the different kinds of bridges, roofs, &c., for railway purposes, manufactured by them. Visited principal bridge works in England and America.

The essential difference between European and American railway bridges is the solidity of the former, due to the large amount of material necessitated by the method adopted in their construction, to the smaller relative proportion of the depth of girders compared with their spans, and to the adherence to the "riveted" in preference to the "pin-connected system." Difference between European and American bridges.

The most striking and at the same time valuable feature to be observed in the designs for American bridges is the great depth of the trusses in relation to their spans; the ratio adopted varying from $\frac{1}{8}$th in small spans up to 100 feet, to $\frac{1}{10}$th in large spans up to 400 feet; whereas the European practice has been generally to make the depth $\frac{1}{10}$th to $\frac{1}{12}$th of the spans, a proportion that may be quite correct for plate girders, which should only be used up to spans of 50 feet, but is not correct for open or truss girders. Striking features. Proportion of depth to span.

In the best American designs the materials are concentrated along the line of strains, and the waste metal, used generally to compensate for the loss of sectional area due to rivet holes, is avoided by using pin-connections. In England the pin-connected system is not in much favor, and the Crumlin viaduct in Wales, constructed on the "Warren" principle is frequently cited as an example of the failure of the system to stand the test of wear and tear due to traffic. This viaduct was almost reconstructed some years Materials always concentrated along line of strains. Pin-connected system not in favor in England. Crumlin viaduct. Reason of failure.

years ago, because it was found after examination that the pinholes in the links of the bottom chord had worn oval. The pins were therefore removed and the struts were riveted to the lower chords. Now this failure was not due to the system, but to the imperfect design in neglecting to make the bearing surfaces of the pins and links larger, thus reducing the pressure, and consequently the wear and tear, within safe and proper limits. The principle is so well understood by American bridge designers that ample allowance is always given in pin-connected structures, not only to resist ordinary wear and tear, but to allow for any decay of material.

American bridges stiffer vertically and better braced than European.

The best American bridges are much stiffer vertically, and are generally better braced than in the various examples to be met with in Europe, and one of the special advantages possessed by the American over European designs of bridges is that of being able to make every part by machinery, ensuring thereby uniformity and exact duplication, and as a consequence the work produced at a less cost. The work can also be put together in place in less time—an object of great importance in isolated localities where labor is high—because there is scarcely any riveting to be done on the ground after the scaffolding has been erected; and even scaffolding is not necessary in some cases, as, for instance, in the new cantilever bridge just opened across the river Niagara, and the Kentucky river bridge, erected by Mr. Shaler Smith without staging.

Erection without scaffolding.

Board of Trade exercises certain amount of control in England.

In England the Board of Trade exercises a certain amount of supervision over railway structures, and has published regulations which must be adhered to in designing railway bridges, wherein the limits of tensile strain to be placed ultimately upon the materials used in their construction are laid down in the following manner:—

Board of Trade (England) Regulations.—Iron and Steel Structures.

Board of Trade regulations for bridge construction.

Tensile strains for iron and steel.

"In a wrought-iron or steel bridge the greatest load which can be brought upon it, added to the weight "of the superstructure, should not produce a greater strain on any part of the material than five (5) tons "when wrought iron is used, or six and a half (6½) tons when steel is employed, per square inch; and the "engineer responsible for any steel structure should present to the Board of Trade a certificate to the effect "that the steel employed is either cast steel, or steel made by some process of fusion, subsequently rolled "and hammered, and of a quality possessing considerable toughness and ductility, together with a statement "of the tests to which it has been subjected.

"The heaviest engines in use on railways afford a measure of the greatest moving loads to which a "bridge can be subjected. These rules apply equally to the main and transverse girders. The latter should "be calculated for the heaviest weights carried by the driving wheels of the locomotive engines.

Wind pressure.

"In all large structures the stability of the work must be such as will provide for a wind pressure of "56lbs. on the square foot.

"Where iron is used for the construction of the abutment and piers which are intended to support or "carry girders of high railway bridges and viaducts, it must be distinctly understood that these abutments "and piers should not consist of cast-iron columns of small size, as 12, 15, or 18 inches in diameter."

American Practice.

American practice regarding wind pressure.

The practice in America with regard to the wind pressure on railway bridges has been nearly uniform for many years, but until recently in England the subject does not appear to have received that amount of attention which it deserves, each engineer using his own discretionary limit. On the Continent of Europe, however, the question of wind pressure has assumed a definite shape in practical bridge-building, especially in France, where the practice is to assume a pressure of wind of 35½lbs. per square foot on the structure with a train standing on it, and 64lbs. per square foot without a train upon it, taking the highest results. The maximum normal strain allowed (8,500lbs. per square inch in tension) includes the strain due to the wind.

Rules adopted in America by professional men.

"The rule generally adopted in America is to allow for a wind pressure of 30lbs. per square foot on the "surface of a train standing on the bridge, assumed to be ten square feet to each lineal foot of train, and to "allow the pressure of 30lbs. per square foot upon twice the vertical surface of one truss, the vertical and "horizontal bracing being proportioned for this pressure. The pressure of 300lbs. to the lineal foot of train "is treated as a moving load, and the pressure on the trusses as a fixed load.

Trusses.

"Trusses of less than 200 feet span are proportioned for a pressure of 50lbs. per square foot unloaded, "and the greatest strains by either methods of computation shall in each case be used in determining the "sectional areas of the bracing.

Piers or towers.

Compressive strains on columns of piers.

Factor of safety.

"Iron piers and the spans carried by them are designed to resist a wind pressure of 30lbs. per square "foot on the train and structure, or 50lbs. per square foot upon the structure alone. The compressive "strains on the leeward columns of the piers are computed with the assumption that the *maximum* load is on "the bridge, and to these must be added the compressive strains produced by the wind, and the columns are "proportioned to resist these combined strains with a factor of safety of four (4). The minus strains on the "windward columns shall be computed with the *lightest* train on the bridge, that cannot be blown off by a "wind force of 30lbs. per square foot, and such a width of base is given to the pier that there shall be no "tension in any of the columns supporting it.

Centrifugal force due to curves.

"If the bridge is on a curve, the centrifugal force due to the maximum load, moving at forty miles per "hour,

" hour, shall be added to the strains arising from wind pressure on the span and pier. To resist strains " computed as above specified, tensile bracing shall be proportioned at 15,000lbs. per square inch; the " shearing sections of pins, bolts, and rivets, at 10,000lbs. per square inch; bending stress of pins at " 22,500lbs. per square inch; rivets in tension at 5,000lbs. per inch; and struts in compression with a factor " of safety of four (4). The end connections of all wind bracing shall be stronger than the bracing itself. " Joints of pier columns shall be fully spliced, so that not less than one-half of the sectional area of the " column is available for a tensile strain. In case the sectional area of a pier column proportioned for the " load, wind, and centrifugal strains combined, with a factor of four (4), is less than the section required " for load and centrifugal strains only, at the specified factor for load stress, the largest section shall be used " in all cases.

Tensile strains.

Shearing sections, &c.

End connections.

" To all strains computed as above for wind bracing, there shall be added an initial stress of 10,000lbs. " in each member, in order to allow for the strains produced in screwing up the rods during the adjustment " of the bracing."—" *Wind Pressure on Bridges*," *by C. S. Smith, Mem. Amer. Soc. C.E.*

Initial stress on wind braces.

Piers.

With regard to the supporting piers of bridges, a variety of systems are adopted, varying according to the locality; but the use of cast iron for the construction of skeleton piers of high bridges has fallen into disuse, wrought iron riveted up in a tubular form, or made rectangular in sections, closed and latticed on one side, being now adopted. The plan of supporting the superstructure on hollow iron cylinders sunk below the river bed by the pneumatic process is a very common one in Europe and in England. Examples may be seen in the piers of the Theiss bridge, in Hungary; the Macon bridge, over the Saone, in France; the Kowna bridge, over the Meinan, in Russia; the Saltash bridge, over the Tamar, in Devonshire; the Rochester bridge, in Kent; and the Chepstow bridge, in Wales. In America the same system was adopted for the piers of the Harlem bridge at New York, and many others. Sinking cylinders by the pneumatic process allows a solid foundation to be ultimately reached which could scarcely be attained by any other method. The same system of air compression is used for sinking caissons for supporting the foundations or piers of bridges in situations where piling would be impossible, as, for example, in the piers of the Brooklyn bridge, New York; the Kansas City bridge, across the Missouri; the St. Louis bridge, across the Mississippi; and the Kehl bridge, opposite Strasbourg.

Bridge piers.

Examples.

Pneumatic process for cylinders.

Caissons.

Examples.

Illustrations of Bridges.

I have appended a few illustrations of different types of first-class bridges which I have collected.

Illustrations.

Plates Nos. 58, 59, 60, is a view of one span of a new bridge now being built across the River Ganges, at Benares, in India, on the Oude and Rohilkund Railway. The superstructure is being made of steel by the Patent Shaft Co., of England, from the designs of Mr. Batho, M.I.C.E., consulting engineer in London. The span illustrated is one of seven, and is 356ft. long, between centres of bearings, and 35ft. deep. This bridge has seven spans of 356ft., and nine spans of 114ft. each. The weight of each 356ft. span is 728 tons, and of each 114ft. span is 115 tons, the total quantity of steel in the bridge being 6,410 tons. The cost of superstructures and cast-iron piers was £18 10s. per ton f.o.b., London. The total estimated cost of the bridge is £550,000. The steel used in the work is manufactured by the Landore Siemens's Steel Co., of ~~Scotland~~ Wales.

Plates Nos. 58, 59, 60.

Benares bridge, India.

Plate No. 61 illustrates three examples of iron lattice-girder bridges and piers on the railway line between Bari and Taranto, in Southern Italy.

Plate No. 61.

Italian railway bridges.

Plate No. 62 illustrates two views of the Meldon viaduct in England, erected by the Patent Shaft Co. The piers are entirely of wrought iron, and the viaduct is built on a curve.

Plate No. 62.

Meldon viaduct, England.

Plate No. 63 illustrates a bridge built by Messrs. Handyside & Co., of Derby, England, for the Grand Trunk Railway of Canada. It is a single-track bridge, having a span of 124ft., and a depth of 24ft., or one-fifth of the span, and weighing 67½ tons.

Plate No. 63.

Bridge for Grand Trunk Railway, Canada.

Plate No. 64 illustrates one of five spans of the Paris bridge, made by Messrs. Handyside & Co., of Derby, also for the Grand Trunk Railway of Canada. Each span carries a single track, is 155ft. long, 8ft. wide at the top, and 12ft. 8in. wide at the bottom, with a depth of 20ft., or one-seventh of the span, and weighing 100 tons per span.

Plate No. 64.

Paris bridge Grand Trunk Railway, Canada.

Plate No. 65 illustrates a view of one of the cantilevers of the Fraser River bridge on the Canadian Pacific Railroad as it lay in the yard of the builders, Messrs. Hawkes, Crawshay, & Co., of Gateshead, near Newcastle-upon-Tyne. This bridge is built on a new principle, the only other examples that I am aware of being the new railway bridge across Niagara, opened for traffic on the 20th of December, 1883, and the bridge now being constructed across the Firth of Forth in Scotland. As I propose to describe and illustrate the new cantilever bridge across the Niagara, I will simply state that the span of the Fraser River bridge is 315ft., and that it is built for a single track. I saw one of the links, 6in. x 1in., composing the bottom chord, tested to nine tons per square inch; it stretched $\frac{1}{16}$ of an inch under that pressure, and returned to its normal length after the pressure was relieved. The price in England was £22 per ton.

Plate No. 65.

Cantilever bridge, Fraser River, Canadian Pacific Railway.

Price in England.

Swing Bridges.

When in England I examined the large swing bridge constructed by Sir Wm. Armstrong across the river at Gateshead.

Gateshead swing bridge.

It

It has two spans of 100ft. each, and is swung either by hydraulic power or steam. It is built upon a central pier of masonry, and has a long pier running both up and down stream built of timber piles braced together and floored. Upon one end of this pier the chimney of the boiler which is used for working the hydraulic machinery is fixed, the flue being suspended from the bracing of the pier. The cost of this structure was £250,000. It is the finest bridge structure in the United Kingdom, the central moving or swing spans weighing 1,450 tons. Vessels pass through this bridge in less than five minutes each.

Plate No. 66. Plate No. 66 illustrates a swing bridge at the entrance to the Sunderland Docks.

The swing bridges, or drawspans, as they are termed in America, are usually made for a single line of railway, even when the line is a double-track, and at the end of the bridge the lines diverge into a double track, but there are no switches, the lines being laid with the rails close together, as illustrated in **Plate No. 67.** Plate No. 67. This plan is also adopted for tunnels when they are constructed for a single line of rails only in connection with a double-track railway.

Sellars' patent live centre. **Sir William Armstrong's arrangement.** The swinging portion of the bridges is arranged upon a different plan in America, some being fitted with Sellars' patent live centre, similar to the plan adopted by him for his turntable. The Armstrong arrangement of turning swing bridges by hydraulic power has not been introduced into America. Sir Wm. Armstrong's reason for using this power was probably because he employs an hydraulic ram in the centre of the table to raise the whole structure off its bearings, and having the water-pressure for this purpose he makes use of the water-engine to turn the bridge. In applying power to bridges which turn without being lifted, the direct application of steam to the turning machinery is much cheaper and better. In Sellars' system of pivot for swing bridges, a circular rack is placed outside the circular rail upon which the bearing wheels supporting the bridge run, and the table is turned by means of pinions gearing into the rack. Provision is made by a system of differential gearing which takes the power direct from the engine and transmits it to the pinions—of which there are two placed on opposite sides of the table—producing an equal strain on each of them.

Direct application of steam better than water power. **Sellars' system.**

Plate No. 68. Plate No. 68 illustrates a large swing bridge at Albany, New York. It was designed and constructed by Messrs, Clarke, Reeves, & Co., of the Phœnixville Ironworks, Pennsylvania, and was built for a double track, having the railway above and the roadway below. The swinging portion or drawspan is 400ft. long, and the side spans consist of two of 250ft., three of 100ft., and five of 36ft. each. The total weight is 2,500 tons.

From inquiries made in America I learn that the best bridge engineers use steel as much as possible for the construction of their bridges, and that the tendency of late has been to increase the weights of their bridges. I append illustrations (Plates Nos. 69, 70, 71) of steel bridges kindly forwarded to me by Mr. George Morrison, C.E., engineer of the Northern Pacific Railroad. Plate No. 69 is a general elevation of a 330ft. span railway bridge, with a depth of truss of 44ft., or a ratio of 7·5 of the span. The details are worth studying, as they embody the most recent practice. The links are of steel, made under Kloman's patent. The bridge is constructed for a single track, is 20ft. wide between the centres of the trusses; is fitted with angle iron rail-guards between the rails, as well as with longitudinal timber guards. The bridge floor is of the usual American type, having crossties 9in. x 9in., spaced about 5in. apart, to which the rails are secured.

Plates Nos. 69, 70, 71. **Mr. Morrison's steel bridges for the Northern Pacific Railway.**

Plate No. 70. Plate No. 70 shows an elevation of a drawspan, also designed by Mr. Morrison, for the same railway. It is 346ft. 5½in. long centre to centre of endpins, and is 32ft. 9in. deep, with a width between centres of trusses of 16ft. 4¾in. This bridge carries the railway across the Snake river.

Snake river drawspan.

Plate No. 71. Plate No. 71 shows a general plan of one of the side spans of the Snake river bridge, 246ft. span, 32ft. 9½in. deep, and 16ft. 4¾in. between centres of trusses.

Snake river bridge.

Mr. Morrison's Bismarck bridge, Missouri river. Mr. Morrison also sent me lithographs of the Bismarck bridge for the same railway, which has just been finished. It spans the Missouri river in two spans of 400ft. each, having a depth of 50ft., or one-fifth of the span, and a width between the centres of the trusses of 22ft. This bridge is built entirely of steel, and was being made in Pittsburg, at the Keystone Company's Bridge works, during the time of my visit to that city in May last.

Cantilever Bridge across the Niagara River.

Plate No. 72. **Cantilever bridge, Niagara.** Plate No. 72 illustrates by sketches the large cantilever bridge just erected across the Niagra river, about 300ft. from the old suspension bridge.

Firth of Forth. **Fraser river.** The principle upon which this bridge is constructed is new, it being the first completed example, although the bridge across the Firth of Forth, 1,000ft. clear span, is being built on the same plan; and the large bridge being built in America over the Fraser river, 315ft. span, for carrying the Canadian Pacific Railway, is another example.

Towers. **Piers.** **Cantilever.** **Span.** **Height.** **Weight 3,000 tons.** The Niagara bridge is supported by two steel skeleton towers 132ft. 6in. high, resting on masonry piers founded on beton "Coignet." The ends of the cantilevers are anchored down to the cliffs by masonry piers 39ft. high. and weighing about 800 tons each. The cantilever beams are supported on the two towers, their arms extending on each side, one end being anchored down to resist the uplifting tendency of a load on the other or overhanging end. The two projecting cantilevers are connected together in the middle of the span by an intermediate girder of 120ft. span, making a total of 470ft. between the towers, the clear span across the river being 494ft. 9in., the longest double-track truss span ever built. The height above the water is 239ft. to the rail level. The total weight of steel and iron used in construction was 3,000 tons, and the bridge is built and designed to carry two freight trains weighing one ton per lineal foot,

foot, one on each track, with a consolidation engine attached to each. Under this load no member of the bridge is strained to more than one-fifth of its ultimate strength, the wind-bracing being made to resist a pressure of 30lbs. to the square foot on a surface equal to double the area of one side of the girders, and the area of the floor system added, as well as the area of the above train assumed, for the purposes of calculation, to be 10ft. in vertical height above the rail level.

Calculated strains.

But the most remarkable feature connected with the bridge is the marvellously short time occupied in its erection. Work was commenced in April, 1883; the foundations were completed on June 20th; the piers in August; the towers in September; the spans in November; and completed on December 20th, 1883, when they were tested with eleven locomotives and a train of eleven trucks, loaded with gravel on each track, the estimated weight being 1,900 tons. The bridge was designed by Mr. C. Schneider, Chief Engineer, assisted by Mr. E. Hayes, engineer of the Central Bridge Works, Buffalo, where the ironwork was made. The total cost of the structure was $600,000=£125,000, and the approaches cost $150,000=£31,250. In comparing the systems upon which bridges are generally constructed in America with those which obtain in Europe, I am of opinion that, with the same margin of safety, an American trussed bridge can be made much lighter than a bridge designed on the European system; at the same time it can be built in less time, and cost very much less to make. Bridges of European design cannot be made so cheaply in America as in Europe, owing to want of an uniform system and special mechanical appliances required for their construction. I append a general specification, drawn up by one of the best bridge engineers in the United States, Mr. Geo. M. Wilson, M. Inst. C.E,, the bridge engineer to the Pennsylvania Railroad Company, which will give some idea of the practice adopted.

Remarkable rapidity of erection.

Commenced April, 1883

Opened Dec. 20th, 1883.

Test load.

Designed by Mr. Schneider.

Cost.

American truss bridges made much lighter than European with same margin of safety.

General specification by Mr. Geo. M. Wilson, M. Inst. C.E.

Specifications for Bridges to be Erected on the * * * *

"These specifications are intended to cover the manufacture and delivery by the contractor (at such "points as may be agreed upon) of the ironwork of all bridges required by the company, whether said bridges "are of the I beam, plate girder or truss form, and varying in lengths of span from 10ft. to 200ft. or over.

"1 bridge, No. 11	55ft.	through	span,	50°	askew	left.
"1 bridge, No. 13	45ft.	deck	"	70°	"	right.
"1 bridge, No. 14	45ft.	"	"	70°	"	"
"1 bridge, No. 27	60ft.	"	"	50°	"	"
"1 bridge, No. 28	60ft.	"	"	60°	"	left.
"1 bridge, No. 33	30ft.	"	"	43° 30′	"	right.
"1 bridge, No. 34	100ft.	through	"			

"The entire work is to be constructed of approved material, and finished in every part in a good and "workmanlike manner, according to the drawings and these specifications, to the full extent and meaning of "the same, and to the entire satisfaction, approval, and acceptance of the Chief Engineer of the "Company, and under the supervision and direction of such agent or agents as he may appoint.

"The engineers or inspectors appointed to oversee the construction of the ironwork shall have full "power, at any time during the progress of the same, to reject any materials that they may deem unsuitable "for the purposes for which they are intended, or which are not in strict conformity with the spirit of these "specifications; also to reject any parts of the ironwork on which the workmanship may, in their judgment, "be defective.

"No alterations or variations from the drawings are to be made unless authorised in writing by the *

"Bills of material, which may be furnished by the company with the drawings, are intended for general "information, and must be checked by the contractor, who must assume all responsibility in ordering his "material.

"In all cases figured dimensions on the drawings are to be taken in preference to scale measurements.

"*Wrought Iron.*

"All wrought iron must be tough, fibrous, and of uniform quality throughout, free from flaws, blisters, "or injurious cracks, and of workmanlike finish. It must be capable of sustaining an ultimate stress of "forty-six thousand (46,000) pounds per square inch on a full section of test piece, with an elastic limit of "twenty-three thousand (23,000) pounds per square inch.

"All iron to be used in tension or subject to transverse strains (except webplates) must have a minimum "stretch of 15 per cent. in a length of 8in.

"All iron to be used in compression, and for webplates not exceeding 24in. in width, must have a "minimum stretch of 10 per cent. in 8in. All webplates exceeding 24in. in width must have a minimum "stretch of 5 per cent. in a length of 8in.

"All iron to be used in tensile members of open trusses, rods, bolts, pins, &c., must be double rolled "after and directly from the muckbar (no scrap will be allowed), and must be capable of sustaining an ulti- "mate stress of fifty thousand (50,000) pounds per square inch on a full section of test-piece, with an elastic "limit of twenty-five thousand (25,000) pounds per square inch, and a minimum stretch of 20 per cent. in a "length of 8in.

"All

" All measurements for stretch are to be taken after breaking.

" All tests are to be made on a standard test-piece 1½in. in width, and from ½in. to ⅝in. in thickness, " planed down on both sides equally, so as to reduce the width to 1in. for a length of 8½in., the ends of the " cut being finished with a fillet. Whenever practicable, the two flat sides of test-pieces are to be left as " they come from the rolls; in all other cases *both* sides are to be planed off.

" All wrought iron must stand the following test:—Cut into strips 1½in. in width, it must be capable of " resisting, without signs of fracture, bending cold by blows of a hammer until the ends of the strip form a " right angle with each other, the inner radius of the curve of bending being not more than twice the thick- " ness of the piece tested. The bending must be done by striking on the ends of the piece and not by coax- " ing over a mandrel, and must stop when the first crack appears.

" All plates, angles, &c., which are to be bent in the manufacture must, in addition to the above require- " ments, be capable of bending sharply to a right angle at a working heat without showing any signs of " fracture.

" All rivet iron must be tough and soft, and pieces of the full diameter of the rivet must be capable of " bending, hot or cold, until the sides are in close contact, without showing signs of fracture.

" All tests will be at the expense of the company if the material complies with these specifications, but " at the expense of the contractor if it fails to do so.

" *Cast Iron.*

" All cast iron to be good, soft, tough iron, free from bubbles, flaws, or other defects; the edges and " angles of castings to be sharp and true, and strictly according to the drawings.

" *Workmanship.*

" All workmanship must be first-class. All abutting surfaces must be planed or turned at right angles " to the axis of the piece, unless otherwise especially shown by the drawings, to ensure even bearing, taking " light cuts, so as not to injure the end fibres of the piece. Both in the shop and during erection at the site, " all abutting surfaces must be brought into close and forcible contact by the use of clamps or other approved " means, before being riveted together. Rivet holes must be carefully spaced and punched, and must in all " cases be reamed to fit, where they do not come truly and accurately opposite; the use of driftpins will " not be permitted.

" Rivets must completely fill the holes, have full heads, and be countersunk where required.

" Reamed holes and turned bolts to be used in the place of rivets in all cases where connections have to " be made in the field.

" All pinholes in pieces which are not adjustable for length must be accurately bored (after the work " is assembled) at right angles to the axis of the piece, unless otherwise shown by the drawings, and no " variation of more than one-sixty-fourth of an inch will be allowed in length between centres of pinholes. " Care must be taken that all the pieces shall be of nearly equal temperature during the boring, to ensure " equal length.

" Eyebars must have perfectly formed heads, be of full thickness in the necks, and be truly straight and " out of wind before boring. Pinholes must be exactly in the centre of the head and in line with the axis " of the bar. Pins must be carefully turned, and no variation of more than one-thirty-second of an inch will " be allowed between diameters of pin and pinhole.

" In cases where rough bolts are permitted, a variation of one-sixteenth of an inch will be allowed " between diameters of pin and hole.

" Roller beds must be planed and rollers turned.

" In case of pinholes and abutting surfaces, mechanical means satisfactory to the inspecting engineer " must be used to ensure the proper relative position of the holes and bearing surfaces in the different pieces " with relation to the axis of each piece.

" Whenever links are to be packed more than one-eighth inch to one foot (⅛″ to 1′) out of parallel with " the axis of the structure, they must be bent with a gentle curve until the heads stand at right angles to the " pin in their intended position, *before* being bored, suitable blocking being used to keep them spaced in " position during the operation of boring.

" Plates and shape iron must be straight, true and free from buckles when in the finished work. Web- " plates in girders must be plain surfaces; no variations greater than their thickness will be allowed when a " straight edge is applied to any position.

" In the erection of the structure, where a number of bars are packed together on one pin, they must be " forced together by the use of screw clamps in an approved manner, and thickening washers used at both " ends of the pin to take up the extra length of pin allowed.

" Washers must also be used wherever required to make the joints snug and tight.

" Links and rods, when tested to breaking, must part through the body, and not through the neck or " pinhole in the head. The process of manufacturing the eyebar, and all other manipulations of material, " to be subject to the approval of the engineer or his authorised agent.

" All

"All bored, planed, and turned surfaces are to be thoroughly coated with a mixture of white lead "and tallow, and all other metal-work to receive one coat first quality *boiled* linseed oil before being "assembled in the shops.

"All surfaces are to be painted with one heavy coat of red oxide of iron, or other suitable paint to be "approved by the Chief Engineer, before leaving the works.

"Free access must be given to the inspecting engineer, or his authorised assistants, for the thorough "inspection of both material and workmanship, and all information that he may need relative to the material "must be furnished him, also the necessary assistance for handling material in the shop for purposes of "inspection.

"Failure to give facilities for inspection whenever so required by the engineer will be sufficient cause "for rejection of any raw or finished material. Test-pieces of iron, properly shaped, are to be furnished by "the contractor whenever required.

"The company reserves the right, through its engineer, to reject any defective material or work, at any "time, until the whole shall have been completed and paid for, notwithstanding the same may have been "previously passed by the inspector.

"*General Conditions.*

"All the work to be done in the best and most workmanlike manner, of approved material, according to "the drawings hereinbefore referred to, and everything necessary for the proper and complete execution of "the work, whether the same may have been herein particularly specified or not, or indicated on the "drawings referred to, to be done and furnished in a manner corresponding with the rest of the work, as "well, as truly, and as faithfully as though the same were herein particularly described and specifically "provided for. Every part of the work to be executed under the direction and subject to the approval of "the General Manager, to whom all questions relating to the intent and meaning of the drawings and "specifications, or of the kind and quality of the materials and work required thereby, shall be referred, and "his decision on any disputed points relative thereto, or to the contract for the work, shall be final, con-"clusive, and binding on both parties.

"*Form of Bid.*

"Bids will be per pound, finished weights. The price per pound to be for the whole bridge complete, "including bracing, abutment plates and all details, ready for erection, and to include the delivery of the "work at a point to be named in the proposal.

"Proposals will also state the length of time during which the price named is to hold good for all "bridges for which the company may furnish plans, and should specify a sliding scale of prices based on the "price of iron, on which a continuous contract may be made for a term of years, in case your company "desire to contract for all or more of the bridge work than herein stated.

"Proposals to be addressed to

"Time—

"Time of delivery of bridges f.o.c. New York, alongside the vessel, in reach of tackle :—

"Nos. 11, 13, and 14	Four weeks after acceptance of proposal.
"Nos. 27, 28, and 33	Six " " "
"No. 34	15th of September next.

"Plans and bills of material can be seen at the Engineer's office, Messrs. Wilson Brothers & Co.'s, 435, "Chestnut-street, Philadelphia, Pennsylvania."

BRIDGE WORKS IN ENGLAND.

Bridge works, England.

During my visit to England I inspected several bridge works; among others those of Messrs. Handyside & Co., of Derby; The Patent Shaft Company's Works, at Wednesbury; and Messrs. Hawkes, Crawshay & Co., of Gateshead. At the two first named works I saw in course of construction the "Robinson" swing bridge, the Morphett-street bridge, and the bridge carrying the railway across the river Angas, at Strathalbyn, as well as several bridges for the Indian States Railways, including the large steel bridge over the Ganges in India; at the latter works I saw a bridge being constructed, under American inspection, for the Canadian Pacific Railway Company. The work turned out by each of the above firms was as good as it was possible to obtain, and the appliances at the Patent Shaft Company's works especially appeared to be equal to any demand that might be made upon them.

BRIDGE WORKS IN AMERICA.

Bridge works, America.

In America I especially visited the bridge works of the Phœnixville Company, at Phœnixville, Pennsylvania; of the Edgemoor Company, at Delaware; and of the Keystone Bridge Company, at Pittsburgh. As a *précis* of the correspondence which took place between the Engineer-in-Chief and the above firms forms the subject of P.P. No. 112 of 1883, I will not repeat it in this report, except to again allude to the practice which I was informed obtains in the States with regard to accepting designs from bridge-building companies in competition. The practice adopted by the leading bridge and railroad engineers is to draft their own designs and specifications, and call for tenders from well-known bridge-making firms to supply and erect the bridges required in accordance therewith, and it is not the practice (except in cases where railroads are built for the purposes of speculation) to allow bridge companies to supply bridges of their own designs, especially where the foundations may require special treatment. The principal railroad companies employ engineers

engineers eminent in their profession to design their bridges, and these companies are now fully alive to the fact that the public are deeply interested and personally concerned in the safety of their railway bridges; they will not therefore erect light and unstable structures simply because they are cheap. It is true that the United States Government have no supervision over such works, but they have, by the provision of the Watertown testing machine, placed within the reach of all manufacturers and engineers, the means of avoiding serious mistakes in construction in time to prevent a great disaster.

Phœnixville Bridge Company Pennsylvania.

The Phœnixville Bridge Company (Messrs. Clarke, Reeves, & Co., engineers) enjoy a high reputation as a bridge-building firm in America, having built several important bridges for railway and other purposes. The company own very extensive works, and make their own iron from the ore, rolling all they require for their own specialty, viz., bridge building, as well as iron required for ship building and other purposes. The company possess machinery sufficient for the production of every variety of manufactured ironwork, the bridge shop alone covering more than an acre of ground, and the machinery used in the bridge construction having been specially designed for the purpose of turning out the most complete work, the exact duplication of the various parts being made a specialty.

Some of the works executed by the company. Girard Avenue.

Plate No. 73. Rondout Creek Bridge.

The same company have built some very large bridges, such as the Lyman viaduct, Connecticut; the La Salle bridge, Illinois; the Girard Avenue bridge, Philadelphia (100ft. wide); and numerous other bridges. They have just completed a large bridge, which I visited when in course of erection across the Rondout Creek, on the line of the New York, West Shore, and Buffalo Railway. It consists of one span of 163ft., one span of 235ft., one span of 255ft., six spans of 50ft. 6in., one span of 60ft. The rail level is 150ft. above the water, and the weight of iron used in its construction is 2,000 tons. The same firm designed and built the Kinzua viaduct, which consists of lattice girders in spans of 61ft., the total length of the bridge being 2,052ft. between the abutments, and the height being 302ft. from the ground line to rail level, over the highest pier. The superstructure is supported upon twenty wrought-iron tressels or towers (similar to those in the Nairne railway viaducts), having an uniform length at the top and bottom of 38ft. 6in., and a width at the top of 10ft., ranging at the bottom in exact accordance with the height. The two highest piers are 102ft. 9in. wide at their bases. The piers are anchored down to the masonry by iron bolts. The floor system is of the usual type of timber crossties adopted for railway bridges in America. The weight of iron used in the construction of this bridge is 4,200,000lbs., or about 1,875 tons. This viaduct was built across the Kinzua ravine on the Bradford branch of the New York, Lake Erie, and Western Railway, and occupied only four months in erection.

Kinzua Viaduct.

Plate No. 74.

Phœnix column a specialty.

The specialty of the Phœnixville Bridge Company is the use of the Phœnix column for struts and posts, of trusses and columns, and although it is acknowledged to be the strongest combination to resist compression, yet, owing to its peculiar shape, it is difficult to make the necessary connections without the use of cast iron, a material which is considered objectionable by many bridge engineers.

Edgemoor Iron Company, Delaware.

My next visit was to the Edgemoor Company's works at Edgemoor, Delaware, where I had an opportunity of witnessing the process adopted by the company in making their eyebars for the lower chords of bridges. All the eyebars are die-forged under hydraulic pressure. The first process consists in upsetting the end of the bar and then flattening it and passing to a vertical press, where the eye is formed in a die, a small hole being then punched through the centre. The bars are then taken to a special machine, where both ends of each bar are drilled to an exact gauge, the machine being designed so as to allow for the expansion or contraction of the bars during the operation of drilling the holes for the pins. The plate and girder work is executed in a most systematic manner by special tools made by the proprietors (Wm. Sellars & Co., of Philadelphia). The plate-punching machine is a very beautiful tool, and so is the machine for cutting the ends of L irons to any desired angle With ordinary care the most perfect work can be turned out from this establishment. The riveting is all executed with Tweddell's hydraulic riveters, for the use of which machines Messrs. Sellars are the licencees in America.

Keystone Bridge Company, Pittsburgh.

The next bridge manufactory I visited was that of the Keystone Bridge Company, in Pittsburgh, Pennsylvania, of which Mr. Gottlieb, C.E., is the President. These shops are arranged in the best possible manner, and although their plant is not quite so good as that at Edgemoor, their shops are better. The plate-punching machine is of the same kind as that used at Edgemoor, in which the rivet-spacing is kept precisely uniform. The machine for turning the ends of the girders is also similar, but the riveting tools are different. At the Keystone works they use chiefly pneumatic riveters, which are very simple, and consist of a cylinder and piston acting upon a pair of toggles, which give the required pressure upon the rivet head. The company also use a few of Tweddell's hydraulic riveters. I had an opportunity of seeing the large bridge, called the "Bismarck Bridge," being built by this company; also the Snake river bridges. The work turned cut by this company is exceedingly good. Among the large bridges manufactured by this firm may be mentioned the following examples:—

Bridges built by the Keystone Company.

Plate No. 75.

The railway bridge over the Ohio river, Cincinnati Southern Railway, main channel span 519ft., swing span 370ft., and two side spans of 300ft., is illustrated on Plate No. 75.

The channel span, 319ft., of railway bridge, Steubenville, on the Pittsburgh, Cincinnati, and St. Louis Railway.

Two spans of 342ft. each, at Parkersburgh, on the Baltimore and Ohio Railway.

The supply of materials and construction of Captain Eads's steel-arch bridge at St. Louis, three spans, 515ft. span each.

Plate No. 75A. Plate No. 75A illustrates railway bridge across Ohio river, Beaver, Pennsylvania.

Plate No. 75B. Plate No. 75B illustrates road bridge across Monongahela river, Pittsburgh.

Before leaving the subject of bridges and the tests applied to their different parts, I will shortly describe the testing machine at the Watertown Arsenal, near Boston, which I was enabled to see through the courtesy of Mr. Wm. W. Evans, C.E., of New York. On arriving at the arsenal, Captain Pitman, the officer in charge, very kindly accompanied me and explained the various specialities in this machine. It was made to the order of the Government by Mr. A. H. Emery, of New York, under certain contract conditions, which will be presently described. It is chiefly used for testing metals of all kind as well as timber, and anyone who is willing to pay the fee for its use can have any design of eyebar, column, strut, or other device tested in this machine, the result of such testing being his own property; but the Government reserves the right to collate this information, though not publishing it without the consent of the owner. The tests conducted up to the present date upon the varied forms of bridge members are quite exhaustive, and there are tons of material lying in the "cemetery," as that portion of the yard is called, that have been tested to destruction. The results of the majority of the tests made are tabulated and published by the Government. I am indebted to Dr. Williams, of the Baldwin Locomotive Works, for copies of the reports of the board appointed by the United States Government on the testing of iron, steel, and other metals.

Watertown Arsenal testing machine.

In 1879 the Government appointed a board for the purpose of subjecting this testing machine to the maximum strains imposed by the terms of the contract, viz., a strain of compression of 1,000,000lbs., or 50 tons, and the rupture of a wrought-iron hammered bar 5in. in diameter, by tension, and if no injury was sustained by the machine, the board was empowered to accept it on behalf of the Government. The machine withstood the contemplated tests and was duly accepted, and it is without question the largest and most delicate testing machine yet produced, combining as it does immense strength, wonderful accuracy, and extreme delicacy. At the trial it was resolved, immediately after the rupture by tension of the 5in. round bar, to prove that the machine was not in any way injured by using it to determine the strain necessary to break a horsehair, and the result agreed perfectly with that given by a small spring balance used for this purpose. The machine consists of a heavy cast-iron head bolted to a foundation 10ft. deep, and two 8½in. screws 48ft. long are used to connect this head with the double-acting straining cylinder mounted upon a truck, and moved by steam power to any desired position, and held in place by four bronze nuts on the large screws. The straining cylinder is connected by pressure-pipes having elbow joints to the cylinder of the accumulator, so that a steady strain without the pulsations of the pumps is brought upon the specimen to be tested. The strain on the specimen is brought directly on to an hydrostatic press, in which the pistons are replaced by diaphragms; and very small pipes filled with alcohol and glycerine connect this press with another smaller one operating a series of levers, and finally a scale-beam, which is balanced by the application or removal of weights effected in the most ingenious and expeditious manner. Before there can be any movement of the indicator of the scale-beam there must be motion in the pieces composing the head (weighing 24,000lbs.)—but so delicately is it balanced, and so slight is the extent of this motion, that a pressure of one pound is sufficient to affect it so as to communicate a visible movement to the indicator. The holders are arranged to hold round and flat bars, and plates up to 30in. in width; and the length of any specimen may vary from 1in. to 30ft.

Board appointed to test machine.

Contract tests 50 tons compression to rupture a 5in. bar by tension.

Largest and most delicate machine in existence.

Description.

Pressure of 1lb. to a machine sufficient to visibly affect indicator.

There are no knife edges whatever in any part of the machine, but thin sheet steel is used in such a manner as to avoid frictional surfaces.

No knife edges used for fulcra of levers or balance.

The price paid for the machine ($31,500=£6,562 10s.) did not in any way compensate Mr. Emery, the inventor and contractor, for the amount of time and money which he has spent in perfecting it; and, even with the drawings already made, and the gauges and patterns already prepared, it would be impossible to produce a duplicate machine for anything like the sum Mr. Emery has received.—*(Extract from report of President of the board to the President of the United States.)*

Price.

Impossible to duplicate machine for the cost price paid for it.

I was given to understand that Congress would probably vote a sufficient amount to reimburse the inventor, and give him a handsome bonus.

In the report just published for the fiscal year ending June 30th, 1882, it is stated that there have been 1,587 specimens tested by the above machine during the year, of which number 855 were for private firms, and 664 on Government account. The former occupied ninety-seven days, the latter 208 days. The private firms were thirty-three in number; and although the number of specimens tested was not so large that they could not have been tested on private machines, yet the parties interested preferred to have the work done on the Government machine because they had greater confidence in its accuracy, and believed that greater care and faithfulness were exhibited in the work done at the Arsenal.

Item No. 19.—RAILWAY STATION CRANES (HYDRAULIC), TURNTABLES, &c.

There is nothing new to record in cranes for station purposes. The best I saw were made by Ransome and Rapier, and are of the same description as those lately brought into use on the South Australian Railways. They are fitted with wrought-iron pillars, cheek pieces, and jibs, the use of cast iron being avoided as much as possible.

Station cranes. Ransome and Rapier.

Hydraulic cranes are extensively used for heavy lifts and for warehouseing in station-sheds, and are all made on the same principle, although differing in detail. The majority of the hydraulic cranes which I inspected were made by Sir William Armstrong and by the Chester Hydraulic Engineering Company.

Hydraulic cranes.

Illustrations

Sir William Armstrong and Hydraulic Engineering Company, Chester.
Plate No. 76.

Illustrations of the various descriptions of cranes made by Sir William Armstrong are given on Plate No. 76. Figure 1 shows a goods-station crane used on the North-Eastern Railway at Newcastle. Figure 2 is a goods-shed crane, with pivots at the top and bottom; this is the simplest and cheapest form of station crane made. Figure 3 is a diagram of an hydraulic crane at the Royal Arsenal at Spezia, which is capable of lifting 160 tons 40ft. high. This crane has the same arrangement of inverted lifting cylinders as that fitted to the large lifting shears at the works of Sir William Armstrong, Newcastle.

Figure 4 represents a movable crane, suitable for dock or wharf purposes, as it can be traversed along the wall to suit the varying positions of the hatchways of vessels. There are over 100 cranes similar to this at the Albert Docks. The most useful size is that to lift about 25 cwts. Figures 5 and 6 represent an hydraulic movable jigger. It is not fitted with a jib, but is worked by hanging a sheave or block to the yardarm of a ship, and leading the rope from the jigger through it and into the hold of the vessel. It is very quick in action. Several of these jiggers are in use on the railway jetty at Wallaroo.

Turntables.

The practice pursued in the construction of turntables does not vary very much in England. They are generally made with wrought-iron girders, connected together, and supported upon a cast-iron centre, having a steel pin bearing upon a steel plate. The best turntables of this description brought under my notice are those made by Messrs. Cowan, Sheldon, & Co., of Carlisle, and Messrs. Ransome & Rapier, of Ipswich.

Cowan, Sheldon, and Ransome and Rapier.
Sellars' turntable, America.
Plate No. 77.

With regard to American turntables, those made by Messrs. Sellars & Co., at the Edgemoor Works, and by the Keystone Bridge Company, at Pittsburg, have the best reputation. The Sellars table (Plate No. 77) consists of a device for carrying the centre bearing on loose steel conical rollers, revolving in a circular path between two steel plates, the lower one being fixed to the supporting frame, and the upper one to the turntable. A 60ft. turntable for locomotives can, if properly set up, be turned empty with a weight of 1¼lb. at the end of the lever used for turning it. The device of the Keystone Bridge Company is very similar, the difference being that the steel conical rollers revolve with end bearings in a light iron ring, by which means they are kept at an uniform distance from each other. They also run between two steel plates, as in the Sellars table; and it is claimed by this company that Mr. T. Piper, who patented the device in 1872, was the original inventor, he being at that time one of the managing proprietors of the Keystone Bridge Company.

Keystone Company turntable, U.S.A.

Item No. 20. — PIERS, WHARVES, BREAKWATERS, CRANES FOR SAME, AND APPLIANCES.

COLOMBO BREAKWATER.

Colombo breakwater.

When at Colombo I had an excellent opportunity of seeing the works of the large breakwater now being carried out there in accordance with the design of Sir John Coode.

The breakwater is made of concrete blocks, set in place by means of large cranes. At the commencement of the season of 1882 2,400ft. of breakwater were completed, and at the end of March of same year an additional length of 962ft. was built, and there is now accommodation for upwards of twenty-five vessels drawing 20ft. The work has been very much retarded owing to the monsoons, which entirely stop all progress until they have ceased.

FLOATING BREAKWATER.

Floating breakwaters have been tried at La Ciotat (between Marseilles and Toulon), and at Brighton, but have not been able to withstand violent gales.

DIFFERENT KINDS OF BREAKWATERS.

Different kinds of breakwaters.

There are three kinds of breakwaters generally constructed when stone (natural or artificial) is used. The rubble "*pierrè perdu*," or mound system, such as at Plymouth, Cherbourgh, and the breakwaters on the River Delaware, in America; the vertical wall system, such as exists at Dover; and the "*pierrè perdu*" foundation, with a masonry superstructure. The objection to the first system is the liability of the stone above low water level to be displaced by the action of the sea, and this has to some extent been guarded against in the Plymouth breakwater by pitching the sea slope with large blocks of stone set in cement; at Cherbourgh by large concrete blocks; and at the Delaware river by large blocks of stone. The Marseilles breakwater combines the use of all the quarried material, by placing the small stones on the bottom, and surrounding them with larger blocks, the outer, or sea slope, being protected by large concrete blocks, similar to those used at Algiers. At Boulogne the breakwater is designed on a mixed system, having a rubble mound below, and a masonry wall above low water, the face of which is perfectly straight, and has only a slight batter and no projections.—*(Annals des Travaux Publics*, 1882.*)*

CHICAGO BREAKWATERS.

When at Chicago I inspected the improvements in the harbor which have lately been made by putting down cribwork to form a breakwater. The total length of the completed work is about 3,000ft. The cribs

are

are each 100ft. long, and rest on piles driven and cut off level at a depth of 14ft. below the surface of the water. Another breakwater is in progress, situated about one mile north of the harbor, for the purpose of protecting the entrance, and of affording a harbor of refuge outside it. The cribs are 100ft. long by 30ft. wide, and 22ft. deep; "but as pile driving in deep water (25 to 32ft.) is too expensive, rubble stone filling "has been adopted instead, and it is believed will afford greater stability and prevent unequal settlement "in the cribwork."—(Report United States Army, 1881.)

GRAIN WAREHOUSING MACHINERY, ALBERT DOCKS, HULL, AND AT LIVERPOOL.

Grain warehouses, Hull Dock.

Through the courtesy of the Chester Hydraulic Engineering Company I am enabled to give an account of the hydraulic machinery used at the Albert Docks, Hull, for warehousing grain, and designed by Mr. E. B. Ellington.

Chester Hydraulic Engineering Company.

Machinery.

The machinery consists of a system of rails laid completely round the warehouse, carried on columns on the upper floor. The rail system is so arranged that it can be divided, for the purpose of working either half of the warehouse independently. On these rails double-bucket tipping trucks are placed, connected by a pitch chain, driven by a Brotherhoods' hydraulic engine. The trucks are filled in passing under the elevator hoppers, and are emptied at any point, either on the floor or into spouts leading to different parts of the warehouse. The trucks are tipped by means of discs fitted to the sides of the buckets which, in travelling along, come into contact with portable curved bars placed where it is required to discharge their contents. There are four elevators in the warehouse, driven by Brotherhood engines, which will lift the grain from the pits below the floor level to the top of the warehouse and discharge their contents into the hoppers from whence the trucks are filled.

Rail system.

Trucks.

Tipping device.

Elevator.

The filling of each truck is effected by the movement of a sliding door under the hopper, actuated by hydraulic cylinders, which are operated by the passing truck, so that the process of filling and discharging the trucks, as well as their movement along the rails, is entirely automatic. By specially arranging the tipping discs on the trucks, and providing one-half of them with differently shaped filling tappets, one-half of the trucks, or all of them, can at will be filled at one elevator; and, with the two systems of rails, four different kinds of grain can be kept entirely separate and stored where required.

How trucks are filled and discharged automatically.

The inventor claims the following advantages for his system:—

Advantages claimed by inventor.

I. Saving in power and cost of warehousing:

II. The slow movement of the working parts, the speed being subject to regulation:

III. The absence of gearing to obtain the requisite speed, lessening thereby wear and tear:

IV. Risk of fire reduced to a minimum, all the moving parts working at a low speed and preventing heating of bearings:

V. The circuit of the trucks can be stopped and started when the load is on.

The quantity of grain brought up by one elevator and warehoused by this system has been 210 quarters per hour, and in one case, during an actual day's work with one elevator, 163 tons were lifted and warehoused in five hours; so that, by working with four elevators and tipping trucks, it is quite possible to discharge a vessel containing 3,000 tons of grain in twenty-four hours, and save the labor of thirty-eight men on the top floor alone.

Work done by one elevator.

Three thousand tons handled by four elevators in twenty-four hours.

This system differs entirely from that which obtains in Liverpool and in the large grain warehouses in America, where the elevators are driven by belting, and the grain is distributed after being weighed in the hopper by means of endless rubber belts running horizontally from the hoppers, and carried to any portion of the floor or turned by spouts into bins. The arrangements for turning off the grain as the belt travels forward, and for transferring it from one belt to another running at right angles, are very simple and effective, no grain being lost in the process. I examined the grain hoists and warehouses at Liverpool, where the hydraulic machinery was erected by Sir William Armstrong. These consist of high towers into which the grain is lifted by jiggers with buckets, holding when full about 19cwts., into hoppers, where the grain as it falls is weighed one ton at a time, and passes by means of the endless belt described above into any portion of the building. The lifts are all hydraulic jigger lifts, and work the grain from the dock to the top of the building (six stories in height), being capable of lifting and handling 3,000 tons per diem. The belts are 20in. wide, and immediately under the hoppers run between two rollers set at an angle, so as to cause the belt to assume a hollow form for the purpose of retaining the grain as it leaves the hopper.

Difference between this and system at Liverpool and America.

Liverpool warehouses for grain.

Hydraulic jiggers lift 3,000 tons per diem.

Travelling belts.

The buildings are entirely of stone, with concrete floors and stone stairs, the only timber used being for temporary screens or sides for separating the different heaps of grain.

Buildings.

GRAIN WAREHOUSES AND ELEVATORS IN AMERICA.

The enormous grain traffic in America has compelled the adoption of simple and speedy measures for dealing with the transport of the grain, which is conducted on a totally different principle from that which obtains in these colonies. This business is managed in America with marvellous skill, and to give an idea of the quantity handled in one city alone (Chicago), I may mention that as much as 140 millions of bushels of grain arrive at, and 135 millions of bushels depart from, Chicago in one year.

Grain traffic—Chicago.

Such a large quantity of grain could not be handled unless special machinery were provided, and for this purpose large storehouses containing elevators are being used. These stores contain from 100,000 to 3,000,000

Grain elevators.

Grain stores and elevators.

3,000,000 bushels of grain. The buildings are usually constructed of timber and are of a great height, divided into bins for the storage of the grain, which is lifted from the cars or vessels, as the case may be, by elevators which deliver it at the top of the building, where it is weighed carefully and then "graded" by a State inspector, so that the grain belonging to any particular individual is not kept separated from that belonging to another, but is turned into the bins whose contents are or should be of an uniform character and value.

State inspector.

Board of Trade buildings, Chicago.

The sale and transfer of this grain is conducted by auction in the Board of Trade buildings in Chicago and in other cities, where the wildest gesticulations and greatest excitement may be witnessed about mid-day when the grain contained in the elevators is offered for sale.

Transfer of grain—how managed.

The transfer of the grain bought is of the most simple character. Supposing that one person buys at the auction 10,000 bushels from another, all that is necessary for the buyer to do is to give payment for it to the seller, who in return hands him a receipt for the 10,000 bushels from the elevator. Now suppose, again, that the buyer wishes to send the grain he has just purchased by a certain route, and there is no connection between the elevator wherein his grain is stored and that route, all he has to do is to get a transfer of warrants entitling him to receive where he requires it his 10,000 bushels of grain of the same grade. All this work of grading and transfer of warrants is performed by State inspectors, who determine the quality and grade it accordingly. The storage charges in the elevator for grain are—One cent to one and a quarter cents for the first ten days, and half a cent per bushel for each additional ten days. There are very large buildings for this purpose at Boston, New York, and Chicago.

Store charges.

Grain elevators, Boston.

I inspected one of the largest grain elevators in Boston, it being about 180ft. in height from the pits to the upper floor, upon which the grain is delivered into bins and weighed. By means of shoots and endless rubber belts, 24in. wide, the grain is carried round the building to any point required, or to the vessels berthed at the different piers at least 600 yards distant from the elevator. The machinery is all driven by wide rubber and canvas belts made by the Boston Belt Company, and is furnished with arrangements for taking up the slack of the belts by pulleys running in frames, actuated by racks and pinions.

The shed on No. 1 pier is 646ft. long and 200ft. wide, enclosing a floor area of 5½ acres, the roof being supported by two rows of iron columns, which carry the lattice girders forming the middle span, and by which the roof is supported. One side of the shed is used for bonded goods, and the other for general merchandise. There is also an upper floor on each side of the shed suspended from the iron lattice girders. The machinery is driven by a vertical quick speed high-pressure steam engine, worked by four boilers having return flues.

WHARF CRANES.

120 ton shears at Sir William Armstrong's.

At the works of Sir William Armstrong, at Newcastle, I was shown a pair of shears worked by hydraulic power, and capable of lifting 120 tons by means of a direct acting ram, 5in. diameter, at the head of the shears. The back leg was moved by a screw worked by hydraulic power. As the shears have a direct lift, no great strain is placed on the back leg.

Priestman's cranes at Millwall Docks.

At the Millwall Docks, in London, Priestman's self-acting bucket cranes are used for discharging grain from the barges, there being upwards of fifty of these machines in operation.

Hydraulic cranes Albert Docks. **Plate No. 76.**

The cranes used at the Albert and Victoria Docks are all hydraulic, and were made by Sir William Armstrong, of Newcastle, and are illustrated in Figure 4, Plate No. 76.

Regent's canal cranes.

Coal shoots

The cranes used for whipping coal at the Regents Canal wharves are of the ordinary 3-ton and 30cwt. type, worked by an accumulator in the usual manner, but each crane has attached and fitted to the inside of the jib, a steelyard with its weights, consisting of half hundred weights, quarters, and pounds fitted into a frame at the lower end of the jib, and so constructed that the weight of each tub of coals is accurately given the moment that the crane is swung round over the hopper, through which it is discharged either into the canal barges or into shoots. At the lower end of these shoots is a small platform, level with the bottom of the ordinary coal cart or wagon, and upon this platform are placed small sack scales immediately under th shoots conveying the coals into the sacks. Suitable doors are made in the ends of these shoots to regulate the quantity required for each sack, which as soon as filled is loaded into the cart or wagon that has been backed against the platform to receive it.

These cranes are all driven by a pair of compound horizontal pumping engines made from the most recent designs of Sir W. Armstrong. The accumulators are situated on various portions of the wharves; and as each wharf belongs to a different proprietor or tenant, the power required for working the cranes is paid for by the persons using them at a given sum per annum, varying according to the quantity of goods handled.

CUNARD STEAMER CRANES, NEW YORK.

Cranes at Cunard Steamers Wharf, New York.

At the Cunard Steamers Wharf, New York, I noticed the very rapid manner in which the cargoes were loaded and discharged by means of a mast guyed to the sheds, and fitted with a long horizontal jib which plumbed the hatchways of the steamers, and worked with wire ropes driven by drums actuated by a pair of high-speed vertical high-pressure engines. Plate No. 78 illustrates one of these cranes.

Plate No. 78.

[For ITEM No. 21, *see* page 39.]

Item No. 22.—DREDGING BY SPECIAL MACHINERY FOR HARD GROUND.

I made several inquiries into this matter during my stay in England, and although I saw a great variety of appliances for dredging soft material, the only dredgers I could hear of that were doing good work in hard ground were those made by Messrs. Simon & Sons, and designed by Mr. Kinniple, C.E., chief consulting engineer for the Greenock Harbor Trust, and the hydraulic dredgers designed by Messrs. Bruce & Batho, of London.

Particulars of the work done by the *Greenock* dredger during 1881-2 were forwarded to me by Mr. Kinniple, and are given below. The dredger *Greenock* was still working at the time I left England (March, 1883), and the cost was 4d. per cubic yard for work which, by other means, cost 7d. The daily expenses were £16, and she could easily dredge 2,000 tons of ordinary soil per diem

Work done by Greenock Harbor Trust Dredger.

Cost.

Capacity.

"GREENOCK HARBOR TRUST.

"*Greenock Harbor Trust.—Extract from Monthly Report on Dredgings at Greenock during May*, 1882.

"The greatest amount of dredgings yet done by the hopper dredger *Greenock* in one day falls to be "recorded this month. On the 24th May she commenced at about 3·30 a.m., and dredged and deposited in "Lochlong 1,025 tons of materials. Returning again to her moorings at 8·35 a.m., she filled her hopper a "second time with 1,000 tons, conveyed this to Lochlong, and returned to her moorings at 2·45 p.m. She "then, for the third time, filled her hopper with 1,000 tons, which she conveyed to Lochlong, and returned "to her moorings at 8 p.m., thus having dredged and deposited in Lochlong within 16½ hours no less than "3,025 tons of soft material, 10½ hours of which time was employed in dredging, and 6 hours in conveying "to Lochlong and depositing the materials, and returning and picking up her moorings.

Dredging 3,000 tons in 10½ hours.

"I may mention also that on other eight days in this month, even although disturbed by the steamers "at the Custom House Quay, and by unsuitable tides at the river embankment, the *Greenock* dredged and "deposited in Lochlong two loads a day of about 1,000 tons each.

"These are good examples of what can be done by the hopper dredger system when working under the "same conditions as the dredgers of the Clyde Trust—that is in ample depth of water, at all times of the "tide, moored in one locality, and dredging in soft materials of almost uniform character and easily lifted. "Had the dredger *Greenock* been specially constructed for working in soft instead of in hard soil, and "provided with larger buckets for this purpose, it is clear, from the experience now had of the hopper "dredger system at Greenock during the last five or six years, that even greater results would have been "attained, and at about half the cost of that of the stationary dredger hopper barge system.

"WALTER ROBERT KINNIPLE, M.I.C.E.,

"Chief and Consulting Engineer to the Greenock Harbor Trustees, &c., &c.,
"Westminster and Greenock."

Dredgings by "Greenock" for June, 1881.

Date.	Where Working.	First Load.	Second Load.	Nature of Materials.
1881.		Tons.	Tons.	
June 1	Channelway Garvel Point	1,625	—	Sand
" 2	Do. do.	1,075	—	"
" 3	Do. do.	1,000	1,050	"
" 4	Do. do.	1,025	—	"
" 5	Sunday	—	—	
" 6	Channelway Garvel Point	1,025	1,000	"
" 7	Do. do.	1,025	1,000	"
" 8	Do. do.	1,037	975	"
" 9	Do. do.	1,025	1,000	"
" 10	Do. do.	1,000	—	"
" 11	Do. do.	1,012	—	"
" 12	Sunday	—	—	
" 13	Channelway Garvel Point	1,025	—	"
" 14	Do. do.	1,025	—	"
" 15	Do. do.	1,050	1,050	"
" 16	Do. do.	1,000	1,025	"
" 17	Do. do.	1,000	1,025	"
" 18	Repairing lower tumbler	—	—	"
" 19	Sunday	—	—	
" 20	———	—	—	
" 21	Channelway Garvel Point	1,037	—	"
" 22	Do. do.	1,000	1,075	"
" 23	Do. do.	1,075	1,062	"
" 24	Do. do.	1,050	1,050	"
" 25	Repairing	—	—	
" 26	Sunday	—	—	
" 27	Repairing	—	—	
" 28	Do.	—	—	
" 29	Do.	—	—	
" 30	Do.	—	—	
		19,511	11,312	=30,823 tons.

BRUCE

BRUCE & BATHO'S HYDRAULIC DREDGERS.

Batho & Bruce's hydraulic dredger. Capacity. First cost small. Several at work in India. Twenty strokes an hour in stiff clay. Fifty cubic feet every 1½ minutes. 2,000 cubic feet an hour. Cost of raising silt in India. Depth at which the dredgers work. Size of a silt dredger. Cost.

The hydraulic dredger of Messrs. Bruce & Batho is a seagoing vessel, arranged for the end of the beam of the excavator to pass through an opening in the bottom of the vessel. An excavator 8ft. in diameter will lift six tons at a stroke, or 130 cubic feet, and requires an opening about 10ft. square. The opening can be closed when the dredger is not working, and the vessel can be used for other purposes. There is no heavy machinery in the bow, such as is usually required to lift the ordinary ladder. Their first cost is much less than bucket or ladder dredgers, and the repairs are small and the working expenses very light. There are several working in India on Government works, in canals and other places. One dredger is working at Ooloobariah, in very stiff clay, the excavator making twenty strokes in half an hour and coming up every time well filled. Another working in a canal for fifteen months brings up 50 cubic feet every 1½ minutes, loading and keeping at work without difficulty twenty boats of 500ft. cubic feet capacity each. The larger "Bruce" dredgers are capable of lifting 2,000 cubic feet per hour, and could excavate from 15,000 to 16,000 cubic feet per day, provided a sufficient number of mud punts were supplied. Silt can be excavated in India at the rate of 3 rupees to 3.8 rupees per 1,000 cubic feet. They will work in any depth not exceeding 35ft. of water. A vessel suited for silt dredging in a river or canal, having a length of 80ft. with a breadth of 18ft. and a depth of 6ft., fitted with a 6ft. excavator capable of dredging to a depth of 16ft. and raising over 100 tons of soil an hour, would cost, complete with engines and accumulator, about £5,000 f.o.b. London.

Seagoing dredger. Cost.

A seagoing vessel with separate propelling engines, about 130ft. long and 26ft. beam, capable of dredging 300 tons an hour from a depth of 25ft., would cost about £17,600 f.o.b. London.

Bruce & Batho's cranes dredger. Plates Nos. 79 and 80.

Messrs. Bruce & Batho have also designed an excellent *hydraulic crane dredger*, which can be worked from a quay-wall or on a barge. The excavator can be fitted with prongs for working in clay instead of with plate blades. This crane dredger is illustrated in Plates No. 79 and 80. The capacity of these crane dredgers varies according to size.

Capacity No. 1.

A No. 1, 4ft. diameter, having a capacity of 16¾ cubic feet, will bring up 30 tons of ordinary silt per hour.

No. 5.

A No. 5, 6ft. diameter, having a capacity of 56½ cubic feet, will bring up 102 tons of ordinary silt per hour.

No. 10.

A No. 10, 8ft. diameter, having a capacity of 134 cubic feet, will bring up 240 tons of ordinary silt per hour.

Cost.

A No. 1 would cost about £500 f.o.b. London.

DOCK DREDGERS.

Dock dredger. Liverpool Dock Company. Capacity, 250 to 300 tons per hour.

For dock dredging I saw a great number of Priestman's patent dredgers working. The Liverpool Dock Company, who have for some time used these dredgers, have just ordered four very large machines to be fitted to one steam hopper barge, thus forming a self-contained dredger, having a capacity of from 250 to 300 tons per hour, at a comparatively small cost.

A modification of what is known in America as the clam-shell dredge is made by Messrs. Rose, Downs, and Thompson, of Hull, under Kingston's patent, and has been extensively used.

AMERICAN DREDGERS.

Plate No. 81. American dredgers.

Plate No. 81 fully illustrates the descriptions of dredgers used in the United States. They are adapted to excavating material ranging from loose rock, gravel, compact sand and clay, to ordinary river silt or deposit, in depths varying from 6 to 60ft., and will elevate the dredged material from 15 to 25ft. above the level of the deck, depositing the material directly from the bucket to the right or left hand at pleasure, without changing the machinery, at distances varying from 10 to 50ft. from the side of the dredge, varying according to the length of the crane used.

DIPPER OR SINGLE SCOOP DREDGER.

Dredger No. 1. Plate No. 81.

Dredger No. 1 has a hull measuring 65ft. in length, 26ft. in width, and 7ft. depth of hold. The engine has two cylinders, 10in. by 16in., operating one shaft, supported on heavy frames. The boiler is of the horizontal locomotive type, 4ft. 1½in. diameter and 14ft. 3½in. long. 5ft. 1½in. high, with forty-four 3in. tubes and a steam dome 3ft. diameter, 3ft. high.

Chains.

The chains are round link cable, 1⅛in. iron, for hoisting, and ⅞in. for backing.

Dipper.

The dipper, or bucket, has a capacity of 2½ cubic yards, struck measure, in ordinary work, and smaller when excavating hard materials.

Capacity.

The capacity of the dredger is 1,200 cubic yards of ordinary river silt, or deposit, per day of ten hours.

Fuel.

For an ordinary working day of ten hours, one gross ton (2,240lbs.) of bituminous coals, or one and a half cords of wood, are required.

Pressure.

The pressure of steam ranges from 60 to 80 pounds, according to the character of the work performed.

Gearing.

The gear wheels are of cast steel, proportioned as 7 to 1 to the engines. Weston's patent disc friction gear is used.

Spuds.

When in operation, the dredger is held firmly in position by means of three spuds (two at the crane end and one at the stern), which are raised by the same power as works the dipper. The

Crane.

The crane is swung by a pair of independent link engines, having their cylinders each 6in. by 12in.

Dipper.

The dipper is also used to move the dredger backwards and forwards during its work. It is operated by a triple chain, shown in the engraving.

Wear and tear.

The wear and tear averages 5 to 10 per cent per annum.

Weight.

The weight of the hull is about 60,000lbs., and occupies in shipment ten square feet 26ft. long. The weight of the engines, boiler, and machinery is about 45,000 pounds.

Operations.

All the operations of hoisting and lowering the dipper, swinging the crane, and moving the dredger backwards and forwards, are performed by one man, who is designated the engineer, and who uses for that purpose three levers, one treadle, and the regulator of the engine.

Working crew.

The dipper is regulated in its movements up and down and in the discharge of its contents by another man, designated the dipper-tender. These two men, with a fireman and a deck hand, constitute the regular working crew.

Where not adapted.

Dredgers of this class are not adapted for working in exposed localities, where the water is rough, or where ground swells prevail, causing rolling and pitching.

GRAPPLE DREDGER.

Dredger No. 4,

Dredger No. 4 is also shown on Plate No. 81, and has a hull 100ft. long, 33ft. wide, and 9ft. deep. Plate No. 81.

Engines have two 18in. cylinders with 24in. stroke. The dredger has a capacity of 3,500 cubic yards of ordinary river soil per diem of ten hours, in depths not exceeding 40ft., and in cuttings of 6ft. or more in thickness. The fuel consumed is about two gross tons of bituminous coals per day. The weight of the hull is about 145,000lbs. For working in compact clay, or boulders, or for breaking up wrecks, drawing piles &c., a special grapple is furnished, see figures 1, 2, 3, and 4, Plate No 81.

Figs. 1, 2, 3, and 4. Plate No. 81.

American Dredging Co.

Dredgers on the above principles have been in constant use in America for the past twenty years, and many valuable improvements have recently been introduced. They are built by the American Dredging Company, Philadelphia and New Jersey.

Clam shell dredger.

The clam shell dredger is most extensively used. It is capable of lifting boulders readily, and cannot be easily disabled in coming in contact with them. It will lift boulders that would disable a ladder and bucket dredger. The details of the bucket are shown on Plate No. 81. These dredgers have been in use for some time in Quebec Harbor, where they do excellent work. Messrs. Kinniple & Morris are the consulting engineers.

Plate No. 81.

Item No. 23.—DOCK CONSTRUCTION, TIMBER AND STONE.

ENGLAND.

During my travels through England, I examined specially the Victoria and Albert Docks, the Poplar Docks, the Avonmouth Dock, the Liverpool Docks and landing stages, and the Barrow Docks.

Royal Victoria and Albert Docks.

Royal Victoria and Albert Docks.

The Royal Victoria and Albert Docks are situated just below Blackwall, the lock being 330ft. long by 80ft. wide, with a depth of water over the sill of 28ft. The Albert Dock has an entrance 800ft. long by 80ft. wide, and a depth of water on the sill of 30ft. They are the largest docks of their kind in the world, and are in direct communication with the Great Northern, London and North Western, Midland, Great Western, and Great Eastern Railways. The docks are three miles long and half a mile wide, and are provided with upwards of 100 hydraulic cranes.

Dry docks.

There are two dry docks in connection with the Albert Docks, of the following dimensions, viz:—

No. 1. 502ft. long, 85ft. wide at the coping, and 62ft. at the floor level. Sill 22ft.; and floor 3ft. below sill.

No. 2. 410ft. long, 77ft. wide at the coping, and 54ft. at the floor level. Sill 22ft., and floor 3ft. below the sill.

They are all built with cement concrete, and are fitted with wrought-iron caissons.

Poplar Docks.

Poplar docks.

I next visited the Poplar Docks and warehouses belonging to the Great Eastern, London and North Western, Great Western, and Great Northern Railways; also the new dock made by the Midland Railway Company, with their warehouses and extensive machinery which are erected on the site of what was known as Green's ship-building yards.

Dock sheds.

Each warehouse faces the basin or canal, and has a shed projecting over the water; and in each opening in the side walls there are 30cwt. hydraulic cranes, used for raising, lowering, and swinging in the usual manner. There are also two platforms under each shed, on each of which there are hydraulic cranes, capable of lifting from 3cwt. to 3 tons, fixed between the columns supporting the various floors; and through the floors are hoists running to the top of the building, as well as apertures formed in them through which

Cranes.

which the hydraulic crane chains, fixed on the top floor, pass from thence for the purpose of hoisting goods to the upper floors.

Hydraulic capstans.

Besides these cranes, numerous hydraulic capstans and rollers are fixed by the side of the lines of rails for the purpose of checking and shunting the railway trucks. On one of the wharves there were fitted

Hydraulic end and side-tipping frames.

hydraulic end and side-tipping tables for discharging coals into barges from the trucks, which are made with large end and side doors, hinged at the top, so as to freely discharge their contents when they are on the tipping frames. All the hydraulic machinery is driven by four (4) pairs of engines, there being six (6) pairs

Engines.

in the engine-house, of which one, and sometimes two pairs, are only used when the traffic is moderate. The engines are all of the Armstrong old type, and belong to the Dock Company, who charge each Railway Company having access to the dock, and for whom a certain space is reserved, in accordance with the quantity of goods passing over the wharves.

Midland Railway Dock and plant.

The Midland Railway Company, finding that they were not able to obtain the requisite accommodation at Poplar, have built a fine dock and erected warehouses, cranes, and machinery, for their own special use, but the works were not quite completed at the time of my visit. The machinery was made by Sir Wm. Armstrong, and combines the latest improvements. There is a telltale in each engine-house, showing when the accumulators are descending, and, by an automatic hydraulic arrangement the steam is shut off from all the engines when the accumulator has reached its extreme height; and as soon as it commences to descend each engine in turn starts automatically to pump it up again.

Plate No. 81A.

Avonmouth Dock.

Avonmouth Dock.

I visited the Avonmouth Dock, which is situated, as the name implies, at the mouth of the River Avon, near Bristol. This dock is 1,400ft. long by 500ft. wide, with entrance locks 454ft. long by 70ft. wide, having a depth of water on the sill of 38ft. at ordinary spring tides, and 26ft. at neaps. These depths

Cranes.

are greater than those of any other dock in the United Kingdom. The dock is provided with travelling and fixed steam and hydraulic cranes, and is in rail communication with the Great Western, Midland, and London and South Western Railways.

Sheds. Elevation capacity.

There are 750,000 square feet of floor space under the sheds, or about seventeen acres, having a storage capacity of three millions of bushels, and there is a large grain elevator worked by hydraulic power capable of delivering 100 tons of grain per hour direct from the ship's hold into the warehouse. The electric light is in use at the dockhead to facilitate the docking of vessels at night.

Liverpool Docks.

Liverpool Docks.

The Liverpool Docks are situated near the mouth of the River Mersey, and occupy upwards of 4 miles of frontage to the river. There are 68 docks, which, with their locks, cover an area of water space equal to 344

Basins.

acres 1,992 yards, and have a lineal quayage of 21 miles 1,496 yards. There are seven basins, having a water space equal to 18 acres 1,441 yards, and a lineal quayage of 1 mile 876 yards, making a total water area of docks and basins of 342 acres 3,433 yards, and a lineal quayage of 23 miles 612 yards. At the

Gridirons.

Clarence Dock and King's Pier there are two gridiron docks; that at the Clarence Dock being 25½ft. broad and 313½ft. long; the gridiron at King's Pier being 26ft. broad and 509ft. long.

Landing stages.

There are also very fine landing stages both at Liverpool and at Birkenhead, but I had not sufficient time to inspect the Birkenhead stages. The Liverpool stage is 2,063ft. long by 80ft. wide, and has seven

Floating bridge.

bridges connecting it with the shore, besides a floating bridge 550ft. long and 35ft. wide, by means of which an easy incline for carriage traffic is maintained at all times of the tide.

Capital invested.

The capital invested in this gigantic property is £15,947,924, returning a dividend of 3 to 4½ per cent.

Management.

This estate is managed by 28 gentlemen, receiving no remuneration whatever. Twenty-four of them are elected by those who pay the dock dues, and four by the Government.

Construction.

The docks now being made near the Canada basin and the Brunswick Dock are constructed of cement

Cranes, &c.

concrete built in courses and coped with granite. Hydraulic cranes are provided where required, one being capable of lifting 100 tons. Lines of rails traverse the docks, connecting them with the various railway

Grain Warehouses.

stations. The grain warehouses have been described elsewhere in this report.

Plate No. 81B.

Barrow Docks.

Barrow Docks.

These docks are situated at Barrow-in-Furness, Lancaster. They are in the immediate vicinity of the large iron ore mines, blast furnaces, rolling-mills, juteworks, and steamship building yards, and of the Bessemer steelworks, at Barrow.

There are four docks, viz.:—

The Devonshire Dock,
The Buccleuch Dock,
The Cavendish Dock (Timberpond), and
The Ramsden Dock and Basin.

Devonshire Dock

The Devonshire Dock is 500ft. long, with a width of entrance of 60ft., and a depth of water on the sill of 25½ft. at spring, and 18ft. at neap tides. The water area is thirty acres.

Buccleuch Dock.

The Buccleuch Dock is 500ft. long, with a width of entrance of 80ft., and the same depth of water on the sill as the Devonshire Dock. The water area is thirty-one acres.

The

The Cavendish Dock is 500ft. long, with a width of entrance of 80ft., and communicates with the Ramsden Dock. The water area is one hundred and forty-two acres. Cavendish Dock.

The Ramsden Dock and basin is 900ft. long, with a width of entrance of 100ft., and a depth of water on the sill of 31½ft. at spring, and 24ft. at neap tides. The water area is seventy-three acres. Ramsden Dock.

There is also a graving dock 500ft. long, by 60ft. in width, and a depth of water on the sill of 22½ft. at spring, and 15ft. at neap tides. There is a large hydraulic crane on the dock side capable of lifting 100 tons, and a large number of smaller sized cranes. The wharves are 200 acres in extent, and are amply provided with hydraulic cranes, capstans, and every appliance required for a large trade. The docks are the property of the Furness Railway Company. Hydraulic cranes. Wharves.

During my visit to these docks, I had an opportunity of seeing the large steel screw steamer the *City of Rome*, built by the Barrow Shipbuilding Company. She had been returned to her builders in consequence of not fulfilling the terms of the contract as to speed, and she had received new boilers, and a new screw of a different pitch, in the belief that by these alterations she would comply with the contract conditions. I have since read an account of her second trip across the Atlantic, in which it was stated that she had made one of the fastest trips on record. *City of Rome* steamer.

Docks Recently Completed.

Among the more recently completed dockworks in Great Britain may be mentioned the new dock at Leith, which cost £400,000 to construct. The dock is 1,500ft. long, by 650ft. in width, having an area of sixteen acres, and a jetty within the dock 1,000ft. long by 250ft. wide. There is also a graving dock built, which is 300ft. long by 48ft. in width. Very extensive additions are projected by the West and East India Dock Company in the dock accommodation of London. This company propose to make docks of sufficient capacity to berth thirty large steamers, each having a length of 400ft., the frontage of the docks being 15,000ft., and having an uniform depth of water of 35ft. Tho erection of the necessary buildings and warehouses it is estimated will cost, including land, £1,100,000. Another proposition, for which authority has been granted by Act of Parliament, is to construct large docks at Dagenham, about four miles below the Victoria and Albert Docks on the Thames, Mr. James Abernethy, C.E., being the engineer. These large works are necessitated by the inadequate depth of water now available, and the new docks proposed will therefore be made with a depth of 35ft. at high water of ordinary spring tides. It is proposed to utilise about 400 acres of land, and the frontage will be about two miles and a half in extent. The entrance will be of sufficient size to allow vessels of the largest size to enter and turn round in the dock. The amount of share capital authorised by Parliament is £1,500,000, with borrowing power to the extent of half a million. Docks recently completed. Leith. Cost. West and East India Dock Company's new docks at Tilbury. Cost. Docks at Dagenham. Necessity for these extensions. Cost.

AMERICA.

Tidal Docks.

Time would not permit me to pursue any investigations into this subject in America, and I am only able to state that all the tidal docks which I saw at New York and San Francisco were built of timber. Tidal docks.

Dry Docks.

I did not see any of the dry docks in the United States, which I much regret, as I was informed that some excellent specimens of timber dry docks were to be seen at Boston, Brooklyn, and Philadelphia, constructed by Messrs. Simpson. Dry docks at Boston, Brooklyn, and Philadelphia.

These docks occupy a very short time in construction and are very durable. There are two or three small sized dry docks built upwards of twenty-five years ago in Boston, and they are at the present time in excellent condition. The docks at the Erie basin, Brooklyn, New York, are fully described in vol. 68, page 15 of the *Scientific American*. They are the most extensive docks in the States, the largest being 580ft. long by a top width of 111ft., and a bottom width at floor level of 46ft., and a depth of 25ft. over the sill at high water. The small dock is 490ft. in length, 124ft. in width at cope level, and has the same depth of water as the larger dock. In excellent condition after 25 years service. Brooklyn Docks the largest in the States. Small dock.

They are built on piles, to which the floor is secured, and extra rows of piles are driven under the keel blocks upon which large longitudinal timbers are laid and covered with a bed of cement concrete. The altars are backed with clay puddle, and the whole of the walls are enclosed with sheetpiling planks, tongued and grooved into each other. The entrance is closed with iron caissons. The docks are emptied by means of powerful centrifugal pumps. Although there are four Government docks constructed of granite, it is not intended to make any extension in the same material, but in all probability timber will be used for this purpose. Built on piles. Altars. Entrance. Government intend to use timber for dock extensions.

The piers and wharves which I observed in New York, Boston, Philadelphia, Chicago, and San Francisco were all built of timber, and were fitted with the usual steam appliances for loading and discharging cargo.

COALING STEAMERS, SAN FRANCISCO.

I also noticed a simple contrivance for coaling steamers as they were lying along the wharves. It consisted of an hydraulic lift, suited for small trucks holding about 10cwts. of coals each, by which the trucks containing the coals were lifted speedily to the height of the eaves of the shed built on the wharf, when they were taken by means of a line of rails laid under and across the roof, to the face of the wharf by a small locomotive, and their contents automatically tipped into coal scoots connected with the bunkers Coaling steamers. Hydraulic lift and railway.

bunkers of the steamers. The gauge of the rails was 2ft., and the work was done in a most rapid manner, avoiding all interruption to the ordinary process of loading or discharging, or interference in any way with the traffic on the wharf.

From the very limited time at my disposal I was unable to visit any of the large piers or breakwaters in the United States.

Item No. 24.—CORNY POINT LIGHTHOUSE.

Soon after my arrival in England I visited Messrs. Chance's lighthouse works at Smethwick, near Birmingham, and discussed the question with the manager of the works, Mr. Kennard, who informed me that the firm had submitted the matter to their scientific adviser, Dr. Hopkinson, whose opinion they would forward as soon as it was obtained. The following letter shows Dr. Hopkinson's opinion :—

"CORNY POINT LIGHTHOUSE, SOUTH AUSTRALIA.

"4, Westminster Chambers, Victoria-street, June 18th, 1833.

Dr. Hopkinson's opinion.

"I cannot be absolutely certain of the exact cause of the false light, but still think it is due to the "reflection from the lantern glass, as the second keeper also does. I would suggest a reply embodying the "following points :—

"1st. We are familiar with the phenomenon of false flashes in the case of revolving lights. These gene- "rally arise from reflection from the lantern glass, and with polygonal lanterns cannot be obviated.

"2nd. We are not so familiar with similar false lights in the case of fixed lights, for the reason that "masked arcs are not very frequent, and that where a distinction of direction is needed, 'red' is the better "and more reliable plan.

"3rd. Two plans proposed by Mr. Russell are inadmissible (*a*), the additional screen, because it carries "the dark arc too far over the sea ; (*b*), the altered lantern, because the incidence of the light on the lantern "glass would be objectionable, being oblique, and because the air space would be reduced.

"4th. The right cure is the other plan suggested by Mr. Russell, and which was also suggested by our- "selves some time since, viz., the use of 'red,' which need not be powerful."

"5th. All they would need to buy would be one frame of upper prisms and a red shade to cover them.

"6th. They could then advertise to show 'bright white' with a feeble 'red' light, which may be "obscured by mist over the rock.

"7th. If we had been advising them as to the character of the light from the first, we should have "recommended to make the 'red' of equal power with the 'white' by means of vertical prisms.

Plate No. 82.

"I return the letters, and also send a sketch (see Plate No. 82), showing how the false light is, in my "opinion, produced exactly as seen.

"(Signed) J. HOPKINSON."

Cost of apparatus for Corny Point.

The cost of the additional upper panel of prisms with the "red" glass plate fitted to it, and prepared to be attached to the existing apparatus, would be £40.

Mr. Kennard also thought it would save future trouble in similar cases if Messrs. Chance Brothers were consulted on the subject prior to ordering, that they might have the opportunity of applying the red light of equal intensity with the white by means of vertical prisms.

Plate No. 83. Diagram of proposal by Messrs. Chance Brothers for a colored sector.

Since my return from Europe, Messrs. Chance Brothers sent a diagram (Plate No. 83) of the optical arrangement they propose to adopt in any future light in which a colored sector may be used to mark a danger—a plan which, in their opinion, will ensure a successful result free from all chance of complication by means of false light or other causes. The line of demarcation is very sharp, the change appearing complete within two degrees, the red light being made as powerful as the white.

Item No. 25.—INQUIRY INTO THE WORKING OF THE ENGINEER'S BRANCH OF THE AGENT-GENERAL'S DEPARTMENT.

During my tour through the various manufacturing districts and the large workshops in the Midland counties and elsewhere, in company with Mr. Meilbek, C.E., of London, the engineer entrusted with the supervision of contracts and materials indented from England, I had abundant opportunity of seeing how the work was being performed. I found, when visiting the various manufactories where contracts were in progress, that the inspection was very thorough, and was performed by competent inspectors, who periodically visited the works and watched the progress of the contracts. Mr. Meilbek is a thoroughly efficient gentleman, perfectly competent to undertake any duties of inspection with which he may be entrusted, and is energetic, active, and never tired of work. I consider the Agent-General may be congratulated upon having secured the services of a gentleman who, as a matter of duty, makes personal inspections of works in hand, and does not ~~relegate~~ delegate this task to his assistant.

Item

ITEM No. 26.—MANUFACTURERS OF BEST AND SECOND BEST BRANDS OF WROUGHT IRON PLATE FOR GIRDER-WORK AND FOR GALVANIZED IRON; ALSO, THEIR RELATIVE MARKET VALUES.

The following is a list of the best brands of wrought-iron plate for girder-work manufactured in England:—

Manufacturing District.	Name of Manufacturers.	Brands.
South Staffordshire	Earl of Dudley, The Priory, Dudley; Round Oak Works, Brierly Hill; and Coneygre Works:	
	Wm. Barrow & Sons, Bloomfield Iron Works, Tipton:	BBH BLOOMFIELD (for plates. Sc.)
	John Bradley & Co., Stourbridge; and Sheetend Works, Kingswinford:	
	Patent Shaft and Axletree Company, Limited, Brunswick Works, Wednesbury:	L F & Co BRUNSWICK P S & A Co
	Philip Williams & Sons, Wednesbury Oak Ironworks, Tipton:	
	Brown & Freer, Ley's Ironworks, Brierly Hill:	
	N. Hingley & Sons, Netherton Ironworks, Netherton, Dudley:	
	E. T. Wright & Sons, Monmoor Ironworks, Wolverhampton:	MONMOOR WRIGHT
North Staffordshire (for angles, tees, and bars only)	Robert Heath & Sons, Biddulph Valley Ironworks, Stoke-upon-Trent:	
	Shelton Bar Iron Company, Stoke-upon-Trent:	
Yorkshire (also for tires, axles, and heavy forgings)	Taylor, Brothers, & Co., Clarence Ironworks, Leeds:	TAYLORS LEEDS
	S. T. Cooper & Co., Kidacre-st., Hunslet, Leeds:	COOPER LEEDS
	Monkbridge Iron Company, Leeds:	MONKBRIDGE
	Kirkstall Forge Company, Leeds:	K M KIRKSTALL
	Parkgate Iron Company, Limited, Rotherham:	PARKGATE
Derbyshire	Butterley Iron Company, Alfreton, Derbyshire:	BUTTERLEY

The

The present ruling rates (December, 1883,) for South Staffordshire iron, are—

	£ s. d.		£ s. d.	
For branded bars	7 10 0	to	8 5 0	per ton.
For North Staffordshire	6 10 0	"	7 10 0	"
For Yorkshire	19 0 0	"	22 0 0	"

GALVANIZED CORRUGATED IRON.

The following list comprises the names of the manufacturers and the brands of galvanized iron, and their relative market values. Gauges 24 and 26, f.o.b., Liverpool or London. 1883.

Name of Manufacturer.	Gauge 24. Price.	Gauge 26. Price.
Gospel Oak Company, 56, Upper Thames-street, E.C.—"Anchor" Brand.	£17 0 0	£12 0 0
	Less 2½ per cent., including packing*	
John Lysaght (Limited), St. Vincent's Iron Works, Bristol—"Orb" Brand.	£15 10 0	£17 10 0
	Less 2½ per cent., including packing.*	
Davies Brothers, Wolverhampton—"Crown" Brand.	£15 10 0	£17 10 0
	Less 2½ per cent, including packing.*	
Frederick Braby & Co., 120, Cannon-street, E.C.—"Sun" Brand.	£15 10 0	£17 0 0
	Less 2½ per cent., including packing.*	
Morewood & Co., Birmingham—"Lion" Brand	£14 15 0	£16 15 0
	Less 2½ per cent., including packing.*	
Ash & Lacy, Birmingham—"Owl" Brand	£14 10 0	£16 10 0
	Less 2½ per cent., including packing.*	
Walker Brothers, Dudley, "Arrows" Brand	—	£16 15 0
	Less 2½ per cent., including packing.*	
Phillips, Gunnett, & Thompson, Birmingham—"Stork" Brand	£14 0 0	£16 10 0
	Less 2½ per cent., including packing.*	
Francis Morton & Co., Liverpool—F.M. L.W. in a △	£14 0 0	£15 5 0
	Less 2½ per cent., including packing.*	
Phœnix Galvanizing and Corrugating Company, Swansea—"Phœnix" Brand	£13 15 0	£15 10 0
	Less 3 per cent., excluding packing, which is about 50s. per ton.	
Wolverhampton Corrugated Iron Company, Wolverhampton—"Emu" Brand.	£13 5 0	£15 5 0
	Less 2½ per cent., excluding packing, which is 50s. per ton.	

* In zinc-lined cases.

ITEM No. 28.—BEST KIND OF DYNAMOMETER FOR MEASURING THE DRAFT OF TRAINS, ESPECIALLY ROUND CURVES.

One of the best kind of dynamometers I have heard of is one designed and described by Mr. Wilder, engineer of the New York, Lake Erie, and Western Railroad in the United States; and I cannot do better than reprint his description and diagrams as they were originally presented to the American Railway Master Mechanics' Association, at a meeting held in the city of Providence, R. I., in 1881 :—

"TRAIN RESISTANCES AND THE DYNAMOMETER.

Mr. Wilder's Dynamometer.

"To the American Railway Master Mechanics' Association:

"Gentlemen—At the request of several members of the Association I would offer a few remarks upon the "subject of train resistances, the dynamometer and its uses. The subject is one on which very little reliable "data has been given, and the factors (to represent the different elements) which are now employed are "generally believed to be altogether wrong. Believing this to be the case, I commenced during the fall "of 1877 to make some experiments and try to solve these questions. We were at that time about to intro-"duce the consolidation type of locomotive into our service, and we wished to know, if possible, its ultimate "capacity in some other way than guess work. Our general superintendent, Mr. E. S. Bowen, and assistant-"general superintendent, Mr. O. Chanute, at that time in charge of our motive power department, gave me "every encouragement, and also allowed the expenditure of some money in the direction of obtaining some

"positive

"positive information of what elements train resistance is composed, and of what proportion each element is "to the whole.

"Starting with a hydraulic weighing machine similar to the one which belongs to this society, I found "that we could not get anything reliable, as it was impossible to get correct readings from which could be "detected the traction, the increase or decrease of speed, also to note the exact spot on the road where "changes in the reading occurred. So I, after many changes, finally designed a dynamometer which we "have found to very accurately record automatically, first, the traction; second, the speed; third, the angle "or direction of the atmospheric resistance in reference to the direction in which the train is moving; and "fourth, the force of the atmospheric resistance in pounds per square foot upon a plane set at right angles to "the line of the atmospheric resistance.

"Besides this there was an arrangement by which the operator could record the mileposts, the length "and position of the curves, stations, and such other information as might be required. The scale on which "this was recorded was 100ft. and 400ft. per inch, as it was required.

"A brief description of the machine may be interesting. It consists of two rollers, which are moved by "gearing which is connected to an axle of the car. Over the roller is drawn a band of paper. As the car "moves along the paper is drawn along to the scale before mentioned.

"Pencils, regulated by springs, are made to move over this band of paper by the action of the different "forces to be recorded, and the speed was recorded by the aid of a clock arranged to open and close a circuit "regularly every ten seconds. The distance between the dots (made by a pencil attached to an armature) "marked by this circuit, showed exactly the speed at all times. The force and direction of the atmospheric "resistance were recorded by pencils moved by a vane, which held a flat disc up at right angles to the line of "atmospheric resistance.

"Most of the experiments were made upon the Buffalo division, but many others have been made. Each "experiment was made with some specific object in view, as to ascertain the full power of engines of different "classes upon different divisions, or to ascertain the amount of power exerted to draw a train over a given "piece of road, and then be able to establish a unit by which to gauge the consumption of fuel. While "these experiments were being made, a careful record was kept of the amount of coal consumed and water "evaporated between the different stops, length of stops, condition of the weather, &c.

"The card showed all of the other data, such as speed at all times, traction force used, direction and force "of the wind or air resistance. These data have to some extent been tabulated, but a change of duties has "prevented my giving the matter any personal attention for some time, and we have not for a year or two "done much but to collect more data.

"I will try briefly to give you some of the information so obtained. We have found that a con- "solidation engine having 20 by 24 cylinders could exert a continuous pull upon the draw bar, exclusive of "the power taken to move herself, of from 18,000 to 20,000 pounds, at a speed of twelve miles per hour. "That for a speed of fifteen miles an hour we could only rely upon from 16,000 to 17,000 pounds; this "reduced to horse power gives about 796. We also found that without the use of sand upon an even dry "rail, with 11,000 pounds upon each driving wheel, the engine was capable of exerting 21,000 pounds of "traction force for use upon the train, and with sand we have attained as high as 25,000 pounds. We found "also that we were able to get as high as 335,278 foot pounds of energy expended in traction per pound of "coal consumed. This is an exceptionally good showing; but when it is considered that the value of this "same coal for work is about 9,000,000 foot pounds, and we are only getting about 3·5 per cent. in effectual "work, and the remaining 96·5 per cent. is lost in converting into steam and then into applied power, and "the loss from the movement of the engine itself (which would be only about 3 per cent.) we are still advised "that there is a large field yet to be explored in the way of economy in the use of fuel. We also found that "in the most of our freight trains, the total resistance, less that due to grade, was about 3·25 pounds per ton, "and that in no case did it exceed 4·5 pounds per ton for the whole length of the road.

"I have brought with me diagrams showing graphically the results of one of our experiments, which "consisted in drawing a train of forty-five cars, weighing 1,100 tons from Buffalo to Jersey City. This train "was drawn on the Buffalo division as far as Castile (57 miles), with two engines, a Consolidation and an "American. From Castile to Hornellsville (34 miles), it was drawn by a Consolidation; from Hornellsville "to Susquehanna (142 miles), by an American engine; from Susquehanna to Summit (8 miles), by three "engines—two Moguls and an American; and from Summit to Port Jervis (96 miles), by one American "engine; and from Port Jervis to Jersey City (86 miles), with a Consolidation, with the help of an American "engine in a few places.

"We found that it required an average of 7,959 pounds for traction for the Buffalo division, 4,198 "pounds for the Susquehanna division, 5,143 pounds for the Delaware division, 5,824 pounds for the eastern "division. Thus showing that on east-bound trains the value of a pound of coal for drawing freight was in- "versely as these figures show, and that an engine should draw as much load the same distance on the Sus- "quehanna division with a little over four pounds of coal as the same engine could on the Buffalo division "for eight pounds, thus giving us a unit for comparison of the different divisions for the same kind of "service.

"The diagrams are on a longitudinal scale of four miles per inch; the grade line is shown on a scale of "400ft. per inch. The traction by a line scaled to 20,000 pounds per inch, and the speed by a line of 60 miles "per

" per inch. I had hoped before this time to be able to publish formulæ for computing the resistance due to the " friction, that due to curve, and that due to the air at the different rates of speed, but I have not been able " to do so as yet. I am perfectly satisfied that we have always considered those resistances due to friction " (and in this I would include that of the bearing and of rolling of the wheel upon the track) and that due " to curves at too high a factor for our present practice, and that we can safely say that it will not average " more than 3½ pounds per ton for friction and $\frac{4}{10}$ pounds per ton for curves.

" Respectfully,

" F. M. WILDER, N.Y., L.E. & W.R.R."

Pennsylvania Railroad dynamometer car.

DYNAMOMETER CAR, PENNSYLVANIA RAILROAD. (Plates Nos. 84, 85, 86, 87.)

Plates Nos. 84 to 87.

I am also able, through the courtesy of the Baldwin Loco. Works, to fully illustrate the dynamometer car, used on the Pennsylvania Railroad, and built at the works of the railway company at Altoona. This car is systematically worked by the officers of the company, who, in October of every year, travel over the entire line, on a track inspection, the gentlemen engaged being divided into committees, who take notes of each division and sub-division on the following points:—Line, surface, joints, ballast, spacing of sleepers, switches, sidings, ditches, road crossings, station grounds, and policing. The number 10 is taken as an unit of absolute excellence, and the men are averaged. The best does not get more than 9, but the general average is high. The men receive a bonus, the highest prize being £10, according to the records. The adoption of this system has a most salutary effect upon the men and the public.

Bonuses for keeping line in order.

The dynamometer car registers automatically the resistance due to the state of the line; it also records the exact time, and rings a bell just before the beginning of each mile is reached. As each division of the railway has its ruling grade, which limits the loads that can be hauled over it, it becomes sometimes a matter of considerable economy to spend some thousands of pounds in reducing this grade to that of the next steepest; and it is one of the uses to which this car is placed, to record the effective resistance due to the grades. During the year 1882-83 this car had run 18,000 miles.

Plates Nos. 88 to 97.

DUDLEY'S DYNAGRAPH AND DYNAMOMETER CAR. (Plates Nos. 88 to 97.)

Dudley's dynagraph and dynamometer car.

There is at the New York Central Station a dynagraph and dynamometer car, the invention of Mr. P. H. Dudley, of New York, and by his special invitation I had the opportunity, in company with a large party of railway officials, civil engineers, and professors from Hoboken College, of travelling in his car and witnessing its practical working in inspecting tracks and automatically marking the rails and joints where repairs are needed. The result of this inspection was most conclusive, as every bad joint, defective sleeper, bad place in the rails, and imperfect packing was instantaneously and automatically recorded on the endless paper travelling under the pens with which the machine was fitted. It was perfectly marvellous to witness the accuracy with which the rails were spotted with different colored paints, indicating to the track inspector the existing defects. The machine is fitted for this purpose with an apparatus termed a "low " joint spotter," by which blue or any colored paint is ejected with considerable force by air pressure upon the underside of the head of the rail where the *permanent depression* and the *deflection* of the joints or rails under the weight of the car exceeds $\frac{5}{16}$ths of an inch. When the depression and deflection is just the amount to which the "spotter" is adjusted the color strikes the point of the greatest deflection; if it is more the spot of paint will be thrown from 1in. to 18in. back from the point of the greatest depression, *i.e.*, in the opposite direction to which the car is running.

Result of inspection.

Low joint " spotter."

Car.

The car is of the ordinary box type, mounted with a six-wheeled bogie truck at one end and a four-wheeled bogie truck at the other end. It is about 44ft. long, 9ft. wide, and of the regulation height.

Dynagraph.

Immediately over the six-wheeled truck is placed the dynagraph instrument, which consists of a cast steel frame carrying the rollers, round which endless paper is wound for the purpose of receiving as it traverses under the machine the records made by the various colored pens with which the upper table of the machine is fitted. The diagram is recorded on the endless paper by pens filled with colored inks and worked by electricity. The number of pens varies from twelve to eighteen, according to requirements. The machine is also fitted with an "aggregating" apparatus, by which the undulations of each line of rails is summed up, and with an apparatus for marking the curves and the super-elevation of the outer rail. It also records any deviation from the proper gauge between the rails; in fact, it absolutely records upon paper the exact condition of the line at the time that the car is passing over it. It is used by Mr. Dudley for the purpose of inspecting the condition of the tracks of the various railroad companies in the Eastern States, and after each inspection he forwards to the general superintendent a condensed diagram of the inspection of the year compared upon the same sheet with the inspection made in the previous year, so that by studying the diagram the superintendent can see at once if any improvement has been made in the condition of the track and its exact location. Mr. Dudley states that "These mechanical inspections being made from a positive base and " under the weight of an ordinary car, give indications of the rails as they came from the rolling mills, or " the forms into which they have developed by more or less years of service; therefore the diagrams present " practical facts as they exist in the tracks, due to a variety of causes—some local, others general.

Aggregating apparatus. Marking curves. Record gauge.

Use.

Mr. Dudley's statement.

Diagrams present practical facts.

" From a collection of diagrams covering many thousand miles of track, under nearly all possible con- " ditions of service, which show the accumulated experience of such roads during the entire use of steel rails; " the marked peculiarities of condition of tracks are plainly seen by comparing diagrams of different roads, " owing to topographical features and the varying qualities of the steel.

" From

" Four very important features are shown by the diagrams :— Important features shown.

" 1st.—Condition of what are called good tracks.

" 2nd.—Quality of the steel.

" 3rd.—What must be expected from service.

" 4th.—The position the road occupies, in some respects, in comparison with other lines.

Mr. Dudley writes again :—"Some of our ablest American and foreign engineers expected that " I would find in our best tracks perfectly surfaced rails, which would bring the ' Condition of track ' " line (on the diagram) nearly to its base. Such facts have not been found, nor can they be, as practical " results from any road or system of permanent way now in use. The 'Lowjoint spotter,' added last year, " painting upon the rails all deflections below a fixed minimum, and its use on 3,000 miles of track, showed " plainly there was a large range of deflections under passing trains, which escaped the attention of the best " trackmen, until the rail commenced to take a *permanent set* at the joints or other portions of the rail. " This is found upon all roads." Large number of defects never detected by trackmen.

One of the most important uses to which this machine is adapted is the determination of the quality of steel in the rails. Any line laid with different brands of steel rails will show a high line on the diagram where the inferior steel is laid, and, therefore, an irregular line per mile; and it is only by such inspection that the deterioration in the quality of the steel used in many of the brands made during the last few years can be readily detected, this deterioration arising from the use of inferior ore, and the adoption of cheaper modes of manufacture. Important use of machine in determining quality of steel in rails.

Mr. Dudley points out, as the result of his experience, that to overcome the breakage of steel rails *hot straightening* has been introduced. The heat-waves ascending from the rails render it almost impossible to see whether they are straight or not, thus resulting in an uneven-surfaced rail, more or less like that shown in figure 3, sheet No. 2, Plate No. 88. He goes on to say :—" *More rails of sufficient hardness for modern* " *traffic are cracked* in improper straightening presses than by service, and to get over this difficulty softer " and milder steel has been made from time to time, until many brands are too soft for present service." Hot straightening condemned. Figure 3, sheet 2. Plate No. 88.

" The condensed diagram of the western division of the Lake Shore and Michigan Southern Railway " shows the most valuable comparisons of recent rails ever presented to railway companies. They are not " personal opinions, but unbiased mechanical exhibits." * * *

" Under modern traffic the ordinary fishplates wear out near the ends of the rails in one or two years, so as " to be of little service, while the ends of the plates are unworn and appear firm and tight to the trackmen." See cut No. 8, sheet 2, Plate No 88. Fishplates wear at the ends of the rails. Cut No. 8, sheet 2, Plate No. 88.

" The ends of rails move up and down under the wheels of the train, and from constant deflections take " a permanent set, developing forms shown in cuts Nos. 2 and 1, sheet No. 2; and unless the joint fastenings " are moved, the ends of the rails are cut out by the service," like those shown in cuts 5 and 6, sheet 2, Plate No. 88. Cuts 1 and 2. Cuts 5 and 6.

Ends of steel rails of good quality are not damaged by traffic, unless the joints are low and loose, and " old rails of good quality of steel can be made to ride nearly as easy as new rails, by putting double angle " plates, as previously suggested." Loose and low joints damage the rails.

Cut No. 10 illustrates a rail of which I saw the original, where the base is worn by the ties and by oxidation, as well as loss of metal in the head from wear due to traffic. Cut 10, worn rail.

Mr. Dudley concludes by recommending modifications in existing sections of rails by giving a stiffer form and a wider and heavier base, having special sections for tunnels, heavy grades, and prominent stations, and states that, from his experience, which has been very great, there is very little difference felt in the riding of cars on rails laid either on the alternate or opposite system of joint, provided the joints are new and firm; but when the joints become worn, the ease of motion is decidedly in favor of the alternate system. Mr. Dudley's recommendation. Special sections for tunnels and heavy grades. Alternate and opposite joints.

Before leaving New York, I requested Mr. Dudley to present me his estimate for constructing a dynagraph and dynamometer car suitable for 5ft. 3in. and 3ft. 6in. gauges of this colony, and I append his estimate for a car for 5ft. 3in. gauge, f.o.b., New York or Boston :— Estimate for car for South Australia.

1. Car body, not less than 44ft. long by 9ft. wide, fitted with Westinghouse automatic brake	$2,000	= £	416	13	4
2. Trucks for ditto	1,000		208	6	8
3. Body of instrument in car, and dynamometrical apparatus complete	3,200		666	13	4
4. Track inspection apparatus	1,500		312	10	0
5. Two aggregating pieces of apparatus for summing up the undulations of each line of rails, at $400 each	800		166	13	4
6. Two low-joint spotters complete	1,000		208	6	8
7. Two extra pumps for same	500		104	3	4
8. Wide gauge truck-marker	500		104	3	4
9. Special truck for curve apparatus	1,500		312	10	0
9a. Duplicates of wearing parts	Nil		Nil		
10. Packing	1,000		208	6	8
11. Testing before shipping	2,000		416	13	4
	$15,000	= £	3,125	0	0
12. Royalty per mile for each mile the instrument is run	·05	= 2½d.			

The

The electrical recorder to be fitted with eighteen pens, and all the moving parts are to be made from tool steel, the frame of the machine being made of cast steel.

The proposition is submitted in detail to allow for the selection of any portion, and the exclusion of others.

In order to test this car in the States, a special truck, 4ft. 8in. gauge, must first be fitted, and the mechanism then transmitted to the 5ft. 3in. gauge truck. If the same car body is used for both the 5ft. 3in. and 3ft. 6in. gauge lines, the cost would be increased by about $6,500 = £1,354 3s. 4d.

Explanation of Plates Nos. 89 to 97.

Plate No. 89.—Figure 1 illustrates an elevation of general recording apparatus as fixed in the car; Figure 2, top view of general recording apparatus; Figures 3 and 4, elevation and plan of recording apparatus and car truck, drawn to smaller scale.

Plate No. 90.

Plate No. 90.—Figures 6 to 16 illustrate the car mounted on the truck, and details of the integrator.

Plate No. 91.

Plate No. 91.—Figures 18 to 21 illustrate the electrical recorder; Figures 22 and 23, the elevation of curve apparatus; and Figures 27 to 31, the lowjoint spotter.

Plate No. 92.

Plate No. 92.—Figures 33 to 38 illustrate the aggregating and summing-up apparatus.

Plate No. 93.

Plate No. 93, gives a specimen form of tabulation of Mr. Dudley's track inspection, with copies of original and condensed diagram.

Plates Nos. 94 to 97.

Plates Nos. 94, 95, 96, and 97, illustrate comparative condensed diagram of an actual track inspection on the New York Central and Hudson River railroad, for the years 1881-82, on the eastern and western division, the Hudson River division, New York to Albany, and the Buffalo and Niagara Falls road. These diagrams show the exact state of the maintenance of way, and give particulars of the ballast, rails, joints, &c.

I cannot conclude this subject without expressing my admiration for the talent, ingenuity, and perseverance displayed by Mr. Dudley in perfecting the above machine, which has proved a great boon to the railway companies in recording mechanically the actual condition of their lines, and enabling them to ascertain the exact causes which lead to any defects, and to apply a proper remedy. I trust I may be enabled to induce the Government of this colony to purchase one of these machines, for the purpose of attempting to reduce, as far as possible, the cost of maintenance on our railways.

Item No. 29.—THE CHEAPEST AND BEST SYSTEM OF FILTERING WATER TO SUPPLY CITIES AND LARGE TOWNS.

On my arrival in London, I found that the Agent-General had been instructed to secure the services of an hydraulic engineer for the colony, and I therefore did not make any inquiries on the subject, it being within the province of the Waterworks Department.

Item No. 30.—THE BEST KNOWN CLOSET-TRAP THAT HAS BEEN IN USE.

I made due inquiries in every town that I visited on the Continent of Europe, in England, and America, with the result that I find "Jennings'" system is believed to be the best. I found that it was closely imitated in Italy, France, and America, where I also saw closets supplied with "Jennings'" pans and traps.

Item No. 31.—WIRE ROPE OR OTHER RAILWAYS FOR HILLY COUNTRY, SUITABLE FOR BRINGING GOODS FROM MINES, QUARRIES, &c., TO MAIN LINE.

Wire tramway, Mount Vesuvius.

Railways or inclines worked by wire ropes are to be found in nearly every country, and are used both for passenger and freight service. The first wire rope passenger railway I saw during my travels was a line running from the base to nearly the summit of Mount Vesuvius. It is worked by a stationary engine and a rope passing round drums in the engine-house and over sheaves along the line of railway, connected with a carriage placed on a frame constructed in such a manner as to keep the floor of the carriage as level as possible. The inclined plane is 2,400ft. in length, on a grade of 1 in 2, and starts from the bottom of the cone of the volcano, at a level of 2,650ft. above the sea. It is made of timber framing, upon which are fixed two longitudinal beams, having one rail laid upon the top and one fastend along the side of each beam; the carriage is mounted upon two wheels, one in front and the other in the rear, and underneath are two guide wheels fixed diagonally on each side of the carriage. On each carriage there is a conductor, who sits in front and works the brake, which, when required, grips the longitudinal timber beams and instantly checks the carriage.

Description.

The

The two ropes used for drawing the carriages are 3in. in diameter, are made from steel wire, and are each composed of forty-nine wires wound round a hemp core. The ropes are attached to the carriage, and running over iron rollers wind round large sheaves, three in number for each rope, one being fixed horizontally and the other two vertically. The rope is driven by a small steam engine, and one carriage ascends one line while the other descends the other line, so that one carriage is always at the top of the incline when the other is at the bottom. The work cost 170 millions of francs. The charges are 4fr. toll and 15fr. for the ascent and descent on the railway. This line is used principally by tourists, and it is lighted by the electric light on poles fixed at stated distances apart.

Cost. Fares.

Similar wire tramways are used in Pittsburgh, U.S.A., for the purpose of ascending from the valley of the river Monongahela to the high land surrounding the city.

Pittsburgh, U.S.A.

Wire rope tramways are used in several localities in England, viz., near London, in Lancashire, and in Yorkshire; that at Messrs. Butterworth's mills, near Rochdale, being a very good example of the system; also that at Messrs. Norton Bros. & Co., Nortonthorpe, near Denby Dale. Mr. W. Carrington, engineer, of London, has constructed several of these wire rope tramways, both in England and abroad, having about fourteen miles or more at work in Spain, thirty miles in the Mauritius, and a good many miles in South America, Norway, France, Cape de Verds, India, Italy, Brazil, and the West India islands. I obtained full particulars of the system from Mr. Carrington, and illustrations of several examples of its application to different purposes are shown on Plate No. 98.

England.

Plate No. 98.

There are three systems of wire rope tramways, viz., the single running rope system, the double fixed rope system, and single fixed rope system. The single running wire rope system consists of an endless wire rope, supported upon a line of pulleys, carried by uprights spaced from 100ft. to 150ft. apart. This rope is wound at one end of the line round a series of drums, actuated by a steam engine, and travels at a speed of about three mile an hour. The load is carried in boxes suspended, and travelling upon the rope by means of a peculiarly shaped hanger, which enable the boxes to pass the pulleys supporting the wire rope. Each of these boxes will contain from 1cwt. to 4cwt., and the speed of delivery is at the rate of about 200 boxes an hour, the carrying capacity of the system being from 10 tons to 500 tons daily.

Single running rope system. Description. Speed of rope. Boxes. Carrying capacity

Special devices are used at each end of the line, whereby the boxes leave the wire rope, and are received on a line of rails laid in as a siding for the purpose. There is no difficulty in passing round sharp corners, or in ascending inclines as steep as 1 in 4.

The chief use to which the system is applicable is to transport ore from mines to the railway, to land or ship goods in harbors or roadsteads, to carry goods from one warehouse to another, to carry agricultural produce on farms, &c. No bridges or expensive cuttings are required; the lines do not occupy much land; they can be readily removed from place to place; and the wire rope can be used as a means of transmitting power as well as removing goods.

Uses.

In Chili a line is at work on the single running wire system, bringing down coals from a colliery situated at the base of a cliff 3,000 yards from the point of discharge. The rope is 1in. diameter, the engine 30 h.p., and the daily duty 120 to 150 tons. The gradients are as high as 1 in 6 and 1 in 7. There is another example to be found at the Cape de Verd Island, where coals are brought from a distance of 500 yards alongside the steamers at the rate of fifteen tons per hour, the same rope being used for working cranes at the termini. The cost of maintenance has been about ½d. per ton, and that of the machinery another ½d. per ton. The cost of the Cape de Verd plant was £2,500. It occupied about three months in erection, and was constructed by Mr. Churchward, Assoc. M.Inst.C.E., from the designs of Mr. Carrington. Mr. Churchward read an interesting paper on the "Monte Penna Wire Ropeway" (Italy) before the Institution of Civil Engineers in London, in the session of 1880.

Chili. Duty. Cape de Verd Islands. Maintenance. Cost of construction.

The double fixed rope system differs from the above in its mode of construction and in working. The ropes are made from crucible steel wire arranged on an incline, anchored at the upper end, and stretched across the space to be spanned by a pair of blocks fitted with flexible steel wire rope. At each end the ropes pass over substantial saddles of masonry. The carriers are boxes made from steel plate, measuring about 2ft. 9in. long by 2ft. wide and 2ft. deep, and are hung on the fixed ropes by a curved hanger fitting into a pair of plates carrying two deeply-grooved steel wheels 15in. diameter. These plates also carry a small safety wheel under the fixed rope. The boxes carry about 14cwt. each. An extensive application of this system is fitted at the Sentein Mines, in the Pyrenees, France, which are situated 7,000ft. above the level of the sea. Mr. Carrington devised the following application of this system: He divided the distance into five inclines—the lower terminals of one joining the upper terminal of the next, and so on to the bottom of the mountain. The spans of the ropes, which are double and stretched parallel with each other, vary from 270 yards to 980 yards, and the fall of each rope 33 yards to 430 yards. The inclines are precisely alike in principle, varying only in length and inclination. The boxes are transported by means of a steel wire hauling rope actuated by the descending load, which pulls up the empty boxes, the speed of the boxes being regulated by a powerful brake. The cost of the works, which were very difficult of execution owing to the rugged character of the mountain, was £5,000.

Double fixed rope system. Ropes. Boxes. Wheels. Sentein Mines. Description. Double ropes. Hauling rope. Cost.

The single fixed rope system consists of a single steel wire rope strained between the termini, and well anchored at each end. This plan is in operation at the London Gas Company's Works at Beckton, where a steel wire rope, having a breaking strain of 40 tons, is strained across the dock, and used to transport about 25 tons of coals per hour across the dock, for a distance of about 150 yards without any support, to the retort-house. The load is taken up an incline of 1 in 15 in buckets carrying 15cwt. each, propelled by a 6 h.p.

Single fixed rope system. Beckton Gas Works. Rope.

Tangye's

Incline. Speeds. Duty. Tangye's engine, at a speed of five miles an hour, tipped into a hopper, and run back again at a speed of ten miles per hour, and brought under the hopper from whence it is re-loaded. The duty performed is thirty-five runs an hour including filling and emptying. The labor is paid for at the rate of 0·88d. per ton. The renewal of ropes, wheels, maintenance, 0·4d., of which the maintenance of the wire rope is 0·26d. In all, except fuel—which is coke supplied by the company to drive the engine—the cost of loading, transport, and discharging, is 1·28d. per ton. The cost of the machinery and engine for the work was £340, the erection and woodwork being provided by the gas company.

Cost of working, &c.

List of prices. The following list of prices was furnished to me by Mr. Carrington :—

	50 tons per ten hours.	100 tons per ten hours.	200 tons per ten hours.
	£	£	£
1. Rope, pulleys, and rolling-stock for a length not exceeding one mile ..... per mile	310	460	530
2. Ditto, not exceeding three but over one mile ..... "	340	490	620
3. Driving and tightening gears with shunt rails, for a tramway one mile or less in length	60	130	170
4. Driving and tightening gears with shunt rails, for a tramway not exceeding three miles but over one mile	120	250	300
5. Angles, giving any degree of deviation	25	35	45
6. Packing	20 to 30	30 to 40	40 to 50

To which must be added the cost of timber posts and engine power. The former average about thirty to the mile, and cost from £3 to £5 each. The engine power varies with the requirements.

Wood frames or masonry for carrying the terminal gear and shunt rails are not included in above prices.

Mode of estimating. To illustrate the method of estimating from above prices, the following example is given, viz. :—

1. Cost required for a tramway three-quarters of a mile long, to carry fifty tons per ten hours with one angle, rope pulleys and rolling-stock as per item No. 1 above, £310 per mile; or for three-quarters of a mile £232 10s.

United States Hoisting and Conveying Machine.

This apparatus is very ingenious and simple in construction and operation. It is specially used for hoisting and transporting to a distance buckets of coals, ores, or packages of goods, which can either be thrown out, or lowered into position with certainty and rapidity, effecting a very great saving in time. Plates Nos. 99 and 100 respectively give a general and a detailed plan of the arrangement.

Plates Nos. 99 and 100.

Plate No. 99. Plate No. 99 shows the method adopted for discharging coals from a barge or ship, and stowing them in a stack on the wharf.

Plate No. 100. Plate No. 100 shows a wire cable strained between two masts, the hoisting machine working with the load moving down the grade. It also shows the machinery arranged for working with the load moving up grade. The action may be described as follows :—

Description. Down grade machine. For working the hoist with a load moving *down grade*, the hoist rope is running free off the drum in the engine-house, and when the engineer checks the hoist drum by throwing the friction band on, the hoist rope assumes the position shown on the engraving by a dotted line, and the dumping lever Z is lifted, and that turns the tub or bucket upside down and discharges the load. The hoist drum then winds in the hoist rope until the machine reaches the end carriage D, when the hook on the hoist block rises up over the throw-off, as marked on the drawing thus, *2. The engineer then eases off the friction band on the hoisting drum, allowing the hoisting rope to run off and the hoist block and empty bucket to descend, when a loaded tub is hooked on, the hoisting drum is thrown into gear again, and the load is hoisted until the long hook on the top of the hoist block engages with the burden-pin on the hook lever of the machine (as shown and marked in the drawings *1), when the hook lever raises and detaches itself from the end carriage D. The engineer now slacks away on the friction band, and the machine with its load runs down grade to the point for discharging the contents of the tub, when the drumhead is again checked, the load deposited, and the machine is returned to the end carriage D.

Speed. The speed of the machine is governed by the dimensions of the hoisting drum and the power of the engine. A fair speed for hoisting is 3ft. per second for running down grade, three-quarters of an inch to the foot, 10ft. per second; and the speed of the machine for winding and drawing back 6ft. per second, or double the hoisting speed.

Up grade machine. To work the *up grade* machine when the machine and its load reaches the end carriage C, the arm on the tub comes into contact with the dump iron on the end carriage C, as shown in the lower left hand corner of the engraving, when the tub turns over and deposits its load. The machine then returns to the lower end of the cable; the empty tub is lowered to the ground, a full tub hooked on, and the operation repeated.

Setting up cable. Swivel. In setting up a cable the tighter it is strained the better it will work. It should be frequently coated with oil, tallow, and blacklead, mixed to the consistency of soft soap. A swivel should be fitted at each end of the cable, and the cable turned over occasionally to equalise the strains and wear upon it.

Block and fall to backstay. The blocks and fall in the backstay are for the purpose of tightening up the cable, and should be four-sheave blocks. The length of the fall rope should be sufficient to give about 6ft. for final tightening up; generally 70ft. of rope is sufficient for this purpose.

The

The following sizes of cables are recommended:— Sizes.

For a span of 200ft. use a steel cable 1½in. diameter.
" " 400ft. " 1¾in. "
" " 600ft. " 2in. "
" " 800ft. " 2¼in. "

The above machines are in extensive use, and are made by the U. S. Hoisting and Conveying Company, 169, Broadway, N. York. Manufactories.

Wire Rope Tramway System, or Cable Roads.

SAN FRANCISCO.

The introduction of the system of traction on tramways, by under-ground cables, is due to Mr. A. S. Hallidie, of San Francisco; and, since the first road was laid down in Clay-street of that city, considerable improvements in detail have been introduced. This system is adapted to every kind of tramway, and can be worked on gradients so steep that it would be impossible to use horse traction. Curves of sharp radius can also be traversed without the slightest inconvenience. It consists of an endless steel wire rope, running over sheaves fixed in a tunnel or tube formed below the surface of the ground, the rope being kept in motion by a stationary engine fixed at either end or in the centre of the distance between the termini, the power being transmitted from the rope to the "dummy" car running on the street rails by means of a "gripper" fixed to the car, and passing down through a narrow longitudinal opening made along the centre of the tramway for this purpose. The gripper is operated by the attendant, who rides in the well of the "dummy" car, and, by a simple backward or forward motion of a lever, he can release the rope, and, by means of the brake, instantly stop the car or start it at pleasure.

Introduction of wire rope tramway system. Can be used on steepest grades and sharpest curves. Description

The Clay-street tramway, laid down in 1873, was the first line constructed on this system. This street is only 49ft. wide, and a double track was laid from the Kearney-street terminus, the lowest point, passing over the intervening rise at Jones-street, as far as Van Ness-avenue, a distance of 5,197ft., the engine-house being fixed at Leavenworth-street, about one-third of the distance from Kearney-street. The steepest grade is 1 in 6, and at each intersection of a cross street (of which there are eleven) a piece of level is introduced, the distance between each cross street being about 413ft.

Clay-street tramway. Grade.

The Clay-street cable is of steel wire, 3in. in circumference, about 11,000ft. long, stretched throughout the whole distance, and running on iron sheaves 11in. diameter, and placed 39ft. apart, in a cast-iron tube or tunnel laid between the rails and below the level of the street. There is a groove three-quarters of an inch wide running along the surface of the street for the entire length of the tube, which is placed out of the centre of the tube, in order that dirt and sand may not fall upon the rope, sheaves, or bearings, as well as to clear the upper sheaves and enable the "gripper" to pass by and under the upper sheaves and over the lower sheaves. (See Plates Nos. 101 and 102.)

Cable. Tube. Groove in street not central with line of tube. Plates Nos. 101 and 102.

At every change of angle at the street crossings the rope is supported on sheaves 4ft. diameter, passing round a horizontal sheave 8ft. diameter, fixed at the lower end of the line, and at the engine-house round two angle sheaves, each 8ft. diameter, which serve to lead the rope to the grip pulleys, also 8ft. diameter, and driven by a steam engine having a cylinder 14in. diameter by 28in. stroke. The boiler is 6ft. long and 4ft. 6in. diameter, and consumes about 1 ton 13cwt. of coals per diem. There is also a duplicate engine and boiler kept as a reserve in case of accident. Sheaves are also fixed in the top of the tube to keep the rope from striking it wherever the incline leaves a piece of level and makes an angle upwards.

Sheaves. Grip pulleys. Engine and boiler. Consumption. Duplicate machinery.

The grip pulleys are furnished on their circumference with jaws, for the purpose of gripping and releasing the rope automatically by its own pressure, thus preventing the rope from slipping.

Grip pulley.

The Hallidie "Gripper" (Plate No. 102) was the first apparatus used for the purpose of seizing the rope, which is always kept running during working hours. It differs from those in use on the Market-street line in San Francisco and from those used in Chicago.

Plate No. 102. Hallidies' "gripper."

It consists of a vertical slide working in a standard fixed to the "dummy" car, and motion is given to it by a screw and handwheel. There is also a smaller screw passing down through the centre of the larger one, which is made hollow for the purpose, for operating the slide. At the lower end of the slide there is a wedge-shaped block which actuates two horizontal jaws, that open and close as the slide is moved backwards or forwards, and close when the vertical slide is drawn up. On these jaws soft cast-iron pieces are fitted so as to grip the rope when they are closed. On both sides of these jaws two small sheaves are attached and held by rubber cushions sufficiently in advance of the jaws to keep the rope away from them, and yet at the same time to lead it fairly between them so as not to touch them. When it is necessary to grip the rope, the slide is drawn up by the action of the smaller screw before referred to, and the wedge at the lower end closes the jaws upon the rope, and at the same time forces back the small guide sheaves on to their rubber cushions. The standard to which the slide is attached is enclosed and retained in an iron bracket on the "dummy" car, and is raised and lowered bodily through an opening in the tube and street by means of the large screw, nut, and handwheel.

Description. Jaws. Grinding sheaves. Standard

The "dummy" is the traction car to which is fitted the bracket and gripping apparatus before described, and it is provided with very powerful brakes, worked by levers. The "dummy" is coupled to the ordinary tramcar, and carries sixteen passengers, the tramcar seating comfortably fourteen passengers. Sometimes the two vehicles carry as many as sixty passengers.

Dummy. Number of passengers carried.

On

Rope run seventeen and a half hours daily.

On the Clay-street line the rope is kept running seventeen and a half hours per diem, at a speed of about six miles an hour; the cars starting every five minutes, except in the afternoon, when they start every three minutes.

Gauge.

The gauge of the line is 3ft. 6in., and the rails are flatfooted, of the ordinary 30lbs. section, set quite flush with the street surface, and presenting a neat and smooth appearance.

Expansion and contraction of rope: how provided for.

At the lower end of the line, the rope is stretched and kept in tension by a counterbalance weight of 3,300lbs., on a double purchase, and by this means the expansion and contraction of the rope is provided for.

California-street tramway.

In April, 1878, a tramway was made in California-street, on the wire rope system. It is 12,000ft. long, and is laid with a double track, with a gauge of 3ft. 6in. It runs over two elevations, the height above the starting point being 265ft. and 235ft. respectively, the valley between them being 125ft. above the base.

Horse tramway converted to cable road.

In 1879 the Sutter-street Tramway Co. of San Francisco converted their horse-traction tramway system into a cable road. This line is three miles long, and is laid with a double track throughout; the gauge is 5ft., and the line rises to a heighth of 167ft. above the starting point.

Market-street tramway.

The Geary-street and Presidio lines are also running, and the most important line in San Francisco, viz., the Market-street tramway, is just completed and equipped with all the latest improvements. It is laid with six miles of double track having over twelve miles of cable in use, and is owned by the proprietors of the California-street line.

Tramways in San Francisco being converted from horse to cable traction.

Although the Clay-street line was constructed along a street with such a steep grade that it would have been impossible to work it by horses, the economy in working the wire rope system has been so thoroughly proved, that all the companies in San Francisco, whether their lines are level or otherwise, have obtained, or are trying to obtain, charters to enable them to convert their lines to the wire rope or cable system.

Market-street tram.

The Market-street line, San Francisco, is a specimen of the latest development of the wire rope system, and differs materially from the others in the construction of the tunnel or tube. A diagram is given on

Plate No. 102.

Plate No. 102, showing this subway, which is formed of cement concrete, 3ft. in depth below the street level, and with an average width of 15in., in which are placed, at intervals of about 6ft., frames or yokes of

Tunnel.

wrought iron, made from old 30 or 40lb. rails, and bent to the form shown on the diagram. This frame

Yokes.

is fastened together at the top by wrought-iron straps, riveted to the frame, and forming a tie and support

Slot.

to which the tramrails are secured; the slot is placed midway between the rails, but the sheaves for carrying the rope are fixed on one side of the centre. The slot is made of two L irons rolled slightly out of square, in order to properly clear the connecting lever or shank passing down through it, and to free the slot

Pulleys.

quickly from any obstruction. The pulleys are made of cast iron, in two pieces bolted together, having pieces of wood, with the grain placed endways, fitted round the circumference to receive the wire rope, and at curves angle pieces are fitted to the frames, carrying conical upright pulleys which are used to guide the gripping arrangement. These conical pulleys are 14in. in diameter at the top and 18in. in diameter at bottom, and are spaced from 8 to 10ft. apart.

Cable.

The cable is made of steel wire 4in. in circumference, in six strands of twenty steel wires each, laid round a core of hempen rope. The strand wires are not twisted before laying, but are put on in a long twist round the hemp core, the object being to prevent, as far as possible, the chafing of the wires on one another, which causes the destruction of the rope. The breaking strain of the cable is from 35 to 40 tons, and it

Cost.

costs about £80 per ton in San Francisco.

Cable-straining apparatus.

The plan adopted on the Market-street line for taking up the slack of the cable differs from that described above, on the Clay and Sutter street lines. It consists of a carriage mounted upon wheels, resting on iron rails fixed upon another carriage mounted upon small iron rollers, which run upon a line of rails laid from the back of the winding-drums to the rear of the building. This lower carriage is fitted with detents or pawls, which drop into the racks fixed to the rails, and serve to take up and retain the slack of the cable. The cable is attached to the upper carriage by passing over a sheave fixed upon it, the sheave being counterbalanced by a weight carried by a rope passing over a pulley at the rear of the upper carriage. The upper carriage travels backwards and forwards upon the lower one as much as 2ft. during the time that the cable is kept in motion, and the amount of this travel varies according to the loads placed upon the cable by the traction of the cars. The cable is taken from the engine-house through concrete and brick tunnels under the street, and passes over large iron sheaves which lead it to the centres of the two lines of rails.

Drums.

The drums round which the cable is coiled, and from whence the motion of the cable is derived, are 12ft. in diameter, overhung, in order that the cables may be readily removed and replaced when required. These drums have semi-circular grooves turned in the faces, to receive the cable, and are driven by a pair of

Engines.

horizontal engines fitted with the "Corliss valve gear." There are two duplicate engines kept in reserve in case of accident.

Elevating sheaves.

In order, before starting the cars, to bring the cable from the sheaves upon which it runs up to the level of the gripping attachment, elevating sheaves are fixed at the starting points inside the tube about 7in. below the street level.

Plate No. 102. Gripper.

The improved gripper (see Plate No. 102) used on the Market-street line differs materially from the Hallidie gripper. In the former the gripping jaws are vertical, and in the latter horizontal. The under jaw of the improved gripper is a fixture as regards its relation to the dummy car, and carries the cable by small brass

brass sheaves; the upper jaw is compressed against the cable by the lever operated in the dummy car, causing the slide carrying the jaw to move downwards. These jaws are made of cast iron, fitted with hard-wood rubbing pieces, to receive the cable. There are also two conical vertical rollers attached to the frame carrying the "gripper," by means of which the cable is thrown off sideways when it is necessary to run round a curve. This is effected by moving the lever to its full extent in the dummy car, and by this means raising the upper jaw and conical rollers at the same time. The cable is also lifted by the rollers and slides off their lower edges, when the rollers are allowed to drop back again into their normal positions, the cable being free from the attachment.

CHICAGO.

State-street, Chicago.

In Chicago, where the above plan has been in full operation, in State-street of that city, since 1882, there are two cables laid, one going north and the other south from the engine-house, and the cars in passing along the front of the engine-house slip the cable on one side, and running on by their own momentum pick up the cable at the other side of it.

Loop line, worked by auxiliary cable. Plates Nos. 101 and 102.

At Wabash-avenue, and Cottage Grove-avenue, the cars are not shunted in the usual manner, neither is the "dummy" car reversed, but an auxiliary cable, driven by the main cable at one-half speed, is used for carrying the cars round a loop and connecting them again with the main cable. This system is shown on Plates Nos. 101 and 102.

Estimated horse-power to work the cable. Keep of horses.

It is estimated that it requires about 5 h.p. to run each train, consisting of two tramcars and a "dummy" car, containing 130 passengers. When the line was opened for cable working, upwards of 400 horses were dispensed with, the keep of each horse being estimated at half a dollar (or 2s.) per diem, including renewals, stable expenses, &c. The 400 horses would cost, therefore, about £40 per diem, or £14,600 per annum.

Fuel.

The fuel used is about 6 tons of coal per day for working a traffic of 190 passengers, and, with the price of coals at 28s. per ton, would cost £8 15s. per diem, to which must be added the wages of engine-drivers, firemen, &c., at say 30s. per day, and we have a total of £10 5s. per day, or £4,000 per annum, to set against the cost of the horses per annum—£14,600; but there is still a further set-off or deduction to be made from this large saving, viz., interest on cost of construction, depreciation, maintenance, &c.

Locomotive and cable systems compared.

Comparing this mode of traction with the elevated railway system, it is found that the locomotive railway consumes 10lbs. of coal per train mile as against 2lbs. of coal per train mile of the cable system of Chicago; the number of passengers carried in both instances being about the same, and the trains running at about the same intervals of time.

Extension and Cost of Cable Roads.

Saving by adopting wire rope instead of horse traction.

The system of working tramcars by means of cables is being rapidly extended in the United States, and a company has been formed in London to work Hallidie's patent on one of the tramway lines. It is an established fact that the wear and tear is much reduced by this system, as well as the entire removal of filth in the street and the abolition of the cruelty practised upon the overworked horses by overloading the cars. The saving effected in San Francisco, as far as I could ascertain, by adopting wire rope instead of horse traction, was from 30 per cent. to 50 per cent. where 200 to 300 horses are employed; and the capacity of the line is practically unlimited. On larger systems the saving is estimated at from 60 per cent. to 70 per cent.

Cost of construction.

I had considerable difficulty in obtaining reliable information as to the cost of construction of these lines, but the cost of the Presidio-road in San Francisco was $210,000, or £43,750. It is two miles long, having a double track laid to a gauge of 5ft., and runs over high hills with cuttings through hard rock, ascending one hill to a height of 246ft. above its base.

The sum of $210,000 includes the cost of land, engine-house, machinery, roadbed, cars, and full equipment.

Average cost. Actual running expenses of a cable road. Average running expenses of a horse line.

I am indebted to the *Tribune* for the following data on San Francisco cable roads: The average cost of building and equipping complete a road on the "Hallidie" system, say for a distance of three miles, would be about $80,000 per mile of double track, or about £16,666. The actual running expenses of a cable railroad of three miles in length, with twenty-four cars and twenty-four dummies, starting from each end every three minutes, including 6 per cent. interest on plant, are $88,246, or £18,384, per annum; or about 36 per cent less than the cost of running a horse road, though with a much greater carrying power. The average running expenses of a horse railroad in the States with a double track, and with a speed of four and a half miles an hour, running thirty-two cars, and starting from each end every three minutes, would be, exclusive of management, $138,000, or £28,750, per annum.

Of course, in a country where labor is high and materials, especially iron, are dear, the cost is much enhanced; but notwithstanding all this, the roads that are opened and running on this system are paying very well.

NEW ZEALAND.

New Zealand.

A wire rope tramway has been lately built in Dunedin, New Zealand. It is 3,500ft. long, and ascends 500ft. in that distance. It is a single track line with two sidings, both parts of the rope running in the same tube or tunnel, except at the sidings. It has two curves of 215ft. radius, forming a figure 8.

ITEM No. 32.—MODE OF EXTINGUISHING FIRES.

ENGLAND.

Fire-escape ladder.

I visited several Fire Brigade Stations in London, and witnessed the men at practice, and also saw them being drilled in the use of the new fire-escape ladder lately purchased by Captain Shaw in America—a machine which will be described under the heading "America."

Bristol Police Fire Brigade.

I also visited the fire arrangements at Bristol, where the police are all drilled firemen, and the fire-engines and appliances are kept at the different police stations ready for use at any moment. The men are practised in the use of the engine and escapes twice a week, and on one of my visits at the head station with the Superintendent (Mr. Coathupe), as soon as the alarm bell was sounded, and without any previous warning, the men turned out, harnessed the two horses to the steam fire-engine, and left the gateway of the barracks in one minute and twenty seconds after the first sound of the alarm bell.

Drill.

The men are also thoroughly drilled in the use of the fire escapes, by which they enter the upper windows of the building in the barrack enclosure and rescue the supposed inmates, impersonated by members of the brigade.

On inquiry I found the system of forming the fire brigade from the police force answered admirably, and as every one of the men is drilled periodically, there is no difficulty in obtaining the full assistance of trained men whenever they are required.

Steam fire-engines.

The best steam fire-engines in use in England are made by Messrs. Merryweather & Sons and Messrs. Shand, Mason, & Co., and are so well known as to render any description unnecessary.

AMERICA.

Electrical facilities.

The fire brigade stations in America are unique, electricity being employed to the utmost possible extent. At the corners of the streets cast-iron posts are erected, which serve as letter-boxes or lamps, to which an electric button is fixed, communicating with the alarm bell of the nearest fire station, so that the superintendent knows at once the quarter in which the fire has occurred. The office is also in telephonic and telegraphic communication with the other fire stations of the city.

Upon the alarm bell being sounded every man takes his station, and in less than twenty seconds the horses start away with the steam fire-engine, and drag it along the streets as fast as two horses can manage to travel. The signal being received in the fire station, the same electrical current releases the trained horses, who at once take up their stations on each side of the pole of the engine, and in some stations (Pittsburgh) the harness is suspended on each side of the pole and over the horses, ready to drop upon their backs as soon as an electric button is touched; all that is then necessary to complete the yoking up of the horses being to clasp together the springs at the bottom of the hames, and attach the reins to the horses' bits by the spring hooks. Should the fire occur during the night when the men are asleep, they are awakened by the bedclothes being suddenly removed by a counterweight controlled by the electrical alarm, while the driver of the fire-engine slides down an inclined shoot through the floor of the sleeping apartment upon the driving box of the engine, his dress and boots (all in one piece) being conveniently placed at the foot of his bed, so that he can put them on before he disappears through the inclined trap.

Fire Ladders and Escapes. (Plate 103.)

Hayes' patent ladder truck. Plate No. 103.

At Chicago I saw some extension ladders and trucks used by the fire station men. They were invented by Mr. Daniel Hayes, of San Francisco, and I witnessed the trial of one of these ladders in Boston. The object of this invention is to provide a ready, safe, and convenient means of sending up or elevating ladders to a greater or less height against a burning building, rendering possible the escape of the inmates, and assisting the firemen in subduing the flames.

Description. 60 to 80ft. high.

Turntable.

The ladder is telescopic, giving a total length of from 60ft. to 85ft from the ground, made in two slides, and worked by an endless chain and winch attached to the lower portion, which is hung on trunnions supported upon an A frame, standing upon a turntable attached to the main frame of the truck.

Raising and lowering series.

Ladder raised by turning screw.

From the under side of the ladder a pair of arms are hung which carry a nut, hung on trunnions, and through the nut a screw passes, one end being held in a swivel, fastened to the revolving portion of the turntable on the front end. The back end extends under the ladder, and the front end is made square to receive a crankhandle, so that by turning the screw the ladder is raised to the required position; the turntable is swung round, and, if necessary, the extension of the ladder is run out, and the ladder lowered against the building.

Truck easily moved.

The truck can be moved about to any point without letting down the ladder, and with a little practice this is done with ease and great rapidity, for in less than one minute the ladders can be raised, fully extended, and placed against a building ready for service. The space occupied by the truck being only from 8ft. to 10ft. in width, it can be worked in a narrow alley as well as in a wide street, and only five to six men are required to work it.

Rope for raising hose.

A rope is provided for raising the hose by means of a hook and a running sheave fixed to the top of the ladder extension, from whence it passes down and under the ladder, through a snatch block fixed to the frame.

An ariel ladder.

As an ariel ladder this truck can be used with safety to a height of the main ladder, or to a height of

50ft. for first class and 40ft. for second class trucks, from the ground. When the ladder is placed in a nearly vertical position, two lines of hose carried to the top can be directed by the firemen to the upper stories of high buildings, giving a decided advantage to the firemen. This truck has been in use in San Francisco for over ten years, and no accident has ever occurred through a failure of the ladder to stand the strains put upon it. The hind wheels are controlled by a cog-gearing operated by a hand wheel, so that the truck can turn very sharp corners and pass up very narrow alleys. The ladders are built of Oregon pine.

In use ten years in San Francisco.

Hind wheels steered by gearing.

The whole apparatus, tools, &c., complete, fitted with an 80ft. ladder, weighs 6,800lbs., and costs $3,500.

Weight and cost.

A truck, with a 40ft. ladder complete, weighs 5,800lbs., and costs $3,000.

They are made by the La France Fire Engine Company, Elmira, New York.

Where made.

One of these ladders was purchased recently by Captain Shaw, the chief of the Metropolitan Fire Brigade of London, after his return from the United States, where he witnessed several trials with this ladder and truck.

In Chicago another system, termed the "Pompier Life-saving System," is used.

Pompier system.

A brief description of the method of drilling the men will explain the mode of operation.

The men are divided into two sections of four each.

Men.

The scaling ladders weigh about 30lbs. each, and are made from a single strip of ash 12ft. to 14ft. in length and 2½in. by 1in. scantling, with a wrought-iron strap screwed to it from end to end to stiffen it.

Ladders.

At intervals of every eighteen inches cross pieces of ash are inserted through the strip forming steps for climbing. At the top of the strip is fixed a piece of steel formed into the shape of a hook, having a straight arm about 4ft. long, turned down at the end to keep it from slipping; the arm is also provided with teeth along its lower edge for the same purpose.

Steps.

Hook.

Four of these strips or ladders are placed parallel upon the floor, and about 4ft. apart; and upon the order being given, "To Ladders, March," four men step out from the rank of the firemen and take their positions in front of the ladders. After going through various exercises tending to harden their muscles, and familiarize the men with the weight and mode of handling the ladders, they adjourn to the rear of the truckhouse, where the scaling exercises are practised upon a line of windows reaching from the first floor to the roof of the building, and prior to commencing, each of the four men before referred to buckles round his waist a belt of webbing, fitted with a large spring hook in front; then, raising their ladders against the wall, they await the orders of the drillmaster. "No. 1, raise and hook ladder," is the second order, when one of the four men lifts his ladder and hooks the end of it over the sill of the second story window. "Prepare to mount! Mount!" is the next order, when the man then climbs his ladder until his breast is about on a level with the sill of the window, and awaits the next order—"stop and fasten," which is then carried out. No. 2, who has been standing with his ladder ready at the foot of ladder No. 1, now, in obedience to orders given, raises his ladder until it can be reached by No. 1, who then lifts it until he hooks it upon the sill of the window of the third story. "Cross over! Mount!" is the next order, when the men climb up the ladders. No. 1 stopping at the third story window, and No. 2 at the second story window. No. 3 now raises up his ladder to No. 2, who in his turn lifts it up to No. 1, and by him it is hooked on to the sill of the fourth story window. No. 1 then begins to climb to the top. In the meanwhile Nos. 2 and 3, having climbed the second and first ladders, No. 4 now passes up his ladder, which is hooked by No. 1 into the cornice of the building, and all four men then climb to the roof.

Drill.
Mode of raising ladders.

The ladders are removed as easily as they were put up, and four men can raise, fix, and take down these ladders in less than two minutes.

Time occupied in raising and taking down.

These scaling ladders are used by the truck men easily and safely, and this system in the hands of trained men has proved to be invaluable, but it would be valueless unless the ladders are handled by competent men.

Must be used by trained men.

Steam Fire Engines.

An excellent steam fire engine, with a quick steaming boiler, is made by the Silsby Manufacturing Company, of Seneca Falls, N.Y., and called the "Silsby Engine." The engine is of the rotary kind, and is made in six sizes, to suit requirements. It is the practice in most fire stations to use heaters for the purpose of supplying the fire-engine with hot water, and for preserving the boiler in a better condition. The heater used with the Silsby engine is made of wrought iron, covered with a Russia iron jacket and a copper water tank. It is automatic in all its parts, requiring no other attention than to shake down the grate and put in a scuttle of coals once during every twelve hours. The connections are self-acting, the forward motion of the fire engine as it leaves the engine-house immediately closing them. It costs packed, f.o.b. cars at Seneca Falls, $200.

Silsby engine.

Automatic heater.

The boilers of these fire engines are of the kind known in America as Silsby's improved circulating tubular, made of steel. The engine and pump are Holly's direct acting, with steel shaft and bronze bearings. The pump has two discharge gates, but they can be coupled, to produce four or more streams of water. There is a sprinkler under the boiler for extinguishing fire which drops through the grate, and the machine is well finished and elaborately nickel-plated. The air chamber is of polished copper, and the suction is always attached to the pump, saving time in connecting with the hydrants. The discharge pipes are fixed over the front wheel of the engine, which is a very convenient situation for the hosemen. This engine will

Boiler.
Engine and pump.
Two discharge gates.

Air chamber.

will throw an inch and three-quarter stream of water 262 feet. One of these engines on trial complied with the following tests:—

Tests.

To throw a stream of water through a 1½in. nozzle and 100ft. of hose from 220 to 245 feet; through a 1½in. nozzle and 500ft. of hose 160 to 185 feet; through a 1½in. nozzle and 1,000ft. of hose 120 to 145 feet; through a 1½in. nozzle from 215 to 240 feet; two 1in. streams from 200 to 225ft.; and four ¾in. streams from 160 to 185 feet.

The time occupied at these trials in raising steam was as under :—

In 2 minutes 50 seconds the indicator of the steam gauge started.
In 3 " 10 " gauge showed 5lbs. of steam.
In 3 " 25 " " 10lbs. "
In 3 " 55 " " 20lbs. "
In 4 " 9 " " 40lbs. "
In 5 " 20½ " water was thrown from the pipe in a good fire stream.

Capacity.

The No. 1 size will throw 900 gallons of water per minute; number of streams, one to four.
The No. 2 size will throw 750 gallons of water per minute; number of streams, one to four.
The No. 3 size will throw 600 gallons of water per minute; number of streams, one to four.
The No. 4 size will throw 500 gallons of water per minute; number of streams, one to four.
The No. 5 size will throw 400 gallons of water per minute; number of streams, one to three.
The No. 6 size will throw 350 gallons of water per minute; number of streams, one to three.

Cost f.o.b. New York.

The prices of these engines are as under :—

Size.	Weight.	Russia iron jacket.
No. 1	7,500lbs.	$4,750=£989 11 8
No. 2	6,800 "	$4,500=£937 10 0
No. 3	6,000 "	$4,250=£885 8 4
No. 4	5,400 "	$4,000=£833 6 8
No. 5	4,800 "	$3,500=£729 3 4
No. 6	4,000 "	$3,250=£677 1 8

Hose coupling. Plate No. 103.

Illustrations are given in Plate No. 103 of the Silsby's patent hose couplings, which are a great improvement upon the ordinary mode of attaching couplings to hose. The hose is secured to couplings by an internal metallic ring expanded in slight corrugations, and preventing the hose from being blown from the coupling by the pressure of the water. The cost per set is $5·00, or £1 0s. 10d.

La France Engine Co.

The La France Fire Engine Co., of Elmira, N.Y., also make a quick-steaming rotary fire engine, weighing about 4,380lbs. On testing one of these engines, which was started with 100lbs. of steam pressure to the square inch, the first water was thrown through 100ft. of hose in five minutes for a distance of 233½ft. with a 1½in. nozzle, and two streams of water through the same length of hose were thrown 180ft. with the same sized nozzles.

Tests.

The steaming test was as under :—

	Minutes.
From first smoke to first steam	1½
" " 5lbs.	1½
" " 18lbs.	2
" " 32lbs.	2½
" " 40lbs.	2¾
" " 47lbs.	3
" " 50lbs.	3½
" " 63lbs.	3½
" " 70lbs.	3¾
" " 80lbs.	4
" " 85lbs.	4·10
" " 90lbs.	4·15
" " 95lbs.	4·25
" " 100lbs.	4·30

Item No. 33.—WELL BORING.

System practised in England. Disadvantages of boring rods for deep sinkin Lining tubes.

The usual system of well boring for moderate depths up to 250ft., practised in England, is by rods connected together with solid bars or hollow tubes. The disadvantages attending the use of solid rods jointed together in the usual manner for deep sinking (say 250ft.) are the constant delays from breakage, due to the crystallization of the iron caused by the continued vibration given to it by the blows of the tool. Lining tubes made from the best iron are always used for deep sinking, and as the success of the well in a great measure depends upon the soundness of the lining, it is the reverse of economy to use inferior tubing.

Mather & Platt's system.

For sinking deep wells the system introduced by Messrs. Mather & Platt, of Oldham, is the most recent, and has been extensively used in England. By this plan the iron rods are done away with, and the old system

system of working with a rope is resorted to. The specialty of Mather & Platt's plan is the method of giving the blow to the tool, and the peculiar form of the tool itself. The method of giving the blow is as follows:—The flat rope used to actuate the tool is wound round a drum, and thence passes over a pulley down to the bottom of the borehole, where it is secured to the tool. The pulley referred to is fitted to a fork attached to the end of a piston working in a vertical steam cylinder. When the rope is down at the bottom of the hole (which is readily accomplished by the man in charge of the drum allowing it to unwind) it is cramped to the framing supporting the steam cylinder, and steam is then admitted below the piston, which forces it to the top of its stroke, carrying the rope, and consequently the boring rod with it. As soon as the piston arrives at the top of the cylinder an exhaust valve is opened, which allows the steam to escape, and the piston-rod, with rope and tool, to fall suddenly by their own weight to the bottom of the hole. The piston in falling is cushioned on steam retained in the cylinder, thereby preventing the piston from striking the bottom. The whole of the machinery is self-acting, and very rapid blows can be given by it to the boring tool. The boring head, or tool, consists of a wrought iron or steel bar, about 4in. or 5in. in diameter, and 8ft. in length, and to the bottom is secured a cylindrical block, having from fifteen to twenty square holes made in it, to receive square-necked chisels or cutters, removable at pleasure, while, at a short distance above this block or cutter head, is another block, used to guide the rod into its proper position. Near the upper end of the rod is another circular block, upon the circumference of which is fitted inclined projections or ribs of steel set spirally, so as to act in a similar manner to a screw with a long pitch, and to assist in turning the boring head as it is lifted in the hole. These projecting ribs cause the head to slightly rotate when they are in contact with the sides of the borehole. The actual rotating mechanism, which is entirely self-acting, is worked by securely fixing one collar on the top of the boring bar, and another about 12in. or 13in. lower down, the under side of the upper, and upper side of the lower, collar being cut with a rachet, similar to that used on the French Bregnet watch keys. Between these two collars a steel bush is fitted to the boring bar, quite free to slide vertically and to revolve, the upper and lower surfaces being cut with teeth corresponding with those in the two fixed collars, but the teeth in the upper face of the bush are cut just half a tooth in advance of the teeth in the lower face. To this bush a bow is fitted, to which the lifting rope is attached. When the bar falls, the bush, having in rising been in contact with the top fixed collar, strikes the teeth in the lower collar just halfway down their inclined surfaces, and in coming into close contact with each other they cause the rope to twist to the extent of half a tooth. In rising, the bush strikes the teeth in the upper collar, and receives another twist backwards equal to half a tooth; the rope therefore has now received a twist equal to the space of one full tooth of the rachet. During the lifting of the tool by the piston the rope, being flat, untwists itself again, and by this means rotates the tool to the extent of a twist at each blow.

Rope system reverted to. Peculiarities of system. Mode of giving the blow to the tool. Steam cylinder. Mode of operation. Boring head. Guide blocks. Partial rotation of head. Rotating mechanism. Rachets. Loose steel bush. Bow for rope attachment. How the twist in the rope is made.

Messrs. Mather & Platt use cast-iron piping to a great extent for their well linings, each pipe being about 9ft. long by $\frac{7}{8}$in. to 1in. in thickness. They are jointed by wrought-iron hoops, 9in. deep and from $\frac{1}{4}$in. to $\frac{3}{8}$in. in thickness, which are fitted to the tubes by turning down the ends to a slight taper when the hoops are shrunk on hot, leaving $4\frac{1}{2}$in. projection to receive the next length of tube. Screws, with countersunk heads, are then used to secure the hoops to the pipes, making the piping practically flush-jointed throughout.

Cast-iron piping with wrought-iron collars. Collars shrunk on hot. Countersunk screws.

Well Boring in the Oil Regions of Pennsylvania.

AMERICA.

The requirements of the oil regions of Pennsylvania have been the means of developing and perfecting the various devices designed for well boring, resulting in the adoption of an almost universal system throughout the district.

Pennsylvania. Universal system in us

I made careful inquiries as to the best machines for sinking deep wells, and I will illustrate and describe those in constant use.

The Plate No. 104 fully illustrates the different tools used, and gives then ames of each portion. A complete set of tools required for drilling a 5in. or 6in. hole is as follows:—

Plate No. 104. Tools required for holes up to 5in. in diameter.

1 auger stem	1 set of small jars	1 sinker bar	1 rope socket
2 small bits	1 temper screw	2 small reamers	2 heavy wrenches

For a larger hole, say up to 8in. in diameter, the following additional tools are requisite, viz.:—

Extra tools for larger holes.

1 set of large jars	2 large bits	1 large reamer

DESCRIPTION.

The auger stem is a round iron bar, with a screwed collar on one end and a screwed pin on the other, its use being to add weight to the stroke of the drill.

Description and use of tools. Auger stem.

The sinker bar is of a similar make, but shorter, and is used for the same purpose as the auger stem.

Sinker bar.

The bits or drills are made from Norway iron, pointed with steel.

Bits.

The reamer is a tool used to follow up the bit in order to enlarge the hole, and keep it true and round. It is made of the same materials as the bit.

Reamer.

The drill jars are screwed on to the top of the auger stem, and are used for lifting the bits and letting them fall in the bore hole. They are made of the same materials as above.

Drill jar.

The rope socket is placed on the top of the tools, and is used to attach the rope or cable which supports the tools in the bore.

Rope socket.

The

Temper screw. The temper screw is suspended from the derrick, and is used to lower the tools in the hole as the drilling progresses.

Wrenches. The wrenches are used for jointing and unscrewing the tool joints.

Besides the above the following tools are necessary, viz.:—

Sand pump. A sand pump to remove sand, dirt, gravel, broken rock, &c., from the hole.

Horn socket. A horn socket, slip socket, and a grab are used to grapple with and extract the different portions of the boring tools which may by accident have been lost or have dropped into the well. The rope grabs are used for grappling for the cable.

Hook. The hook is used for grappling for tools that are lost or stuck or leaning against the side of the borehole. The rope knife is used to cut the rope in the well.

Swivel. The swivel is used for the rope at the top of the hole.

Winged substitute. Hollow and star reamers. The winged substitute is used to keep the hole straight, the hollow and star reamers to straighten a crooked hole, and the slip spear to fish up the tubing.

Slip spear. Well rig or derrick irons. Plate No. 104. The illustrations also show the well rig, or derrick irons, as they are termed, used for working the rope attached to the tools. Plate No. 104 also shows the machinery erected for drilling and for driving the piping.

Mode of drilling. The mode of drilling a well is described as follows:—

Conductor. If the rock is only from 10ft. to 15ft. below the surface it will be unnecessary to drive a lining pipe, but a "conductor" hole is sunk or dug down to the rock, upon which is placed a "conductor" made of 2in. planks, about 8in. square inside measurement, the top of this box being level with the derrick floor. As soon as the conductor is finished, the "rig," as it is commonly termed, is commenced.

Derrick. "This consists of derrick, engine and boiler house, and band wheel house. We will give the dimensions "of these as they are built here in the oil region, where they use very heavy tools and long auger stems and "sinker bars for the purpose of drilling depths of from 1,000ft. to 2,000ft. or more, and also for fast drilling. "The height of a derrick would of course depend upon the length the tools measured when swung up in the "derrick, 58ft. or 60ft. being the usual length when all screwed together.

"With this length of tools—the auger stem and sinker bar 3½in. in diameter—the heft of the tools is made "as great as practicable, as it is advisable to have the tools as heavy as possible, and yet not so heavy as to be "awkward to handle, as the heavier the tools are, of course the faster one can drill, and the greater the heft is "above the more power is brought to bear upon the bit that perforates the rock below. When the sized tools "we have mentioned are used, the derrick is usually built 72ft. high, 20ft. square at the base, tapering to 3½ "or 4ft. square at the top. Heavy timbers, called mudsills, are placed for a foundation, to which are spiked "2 x 8 and 2 x 10 plank for the corners and plank covering, the mudsills serving for a floor, with conductor "hole in the centre.

Engine-house. "The engine-house is usually about 12ft. by 16ft. square, large enough to cover engine and boiler nicely "and have some room left for fuel. The band wheel house is made narrow, to cover belt running from "engine to band wheel, and is about 20ft. long. After the derrick is built, the bull wheel is put in position, "and sampson post and walking beam (after rig irons are put on) are also placed in position, the band "wheel, tug pulley, and sand pump reel are next fixed, and then the band wheel house is boarded up.

Rig. "After a rig is completed and all the machinery placed in its proper position, if a conductor hole is all "that is necessary, and no pipe is to be driven, the next thing in order is to begin spudding, a term applied "to the work necessary to be done while the tools are being worked by hand and continued until the hole is "deep enough to admit of the whole string of tools passing below the surface of the ground.

Spudding. "Spudding is commenced by screwing the bit to the auger stem, the auger stem to the jars, the jars to "the rope socket, and the rope socket being made fast to a cable after running the cable from the bull wheel up "into the top of the derrick over the crown pulley and down into the derrick again. The bull rope is then

Bull wheel. "adjusted. (The bull rope is a heavy cable running from the tug pulley to the bull wheel.) Start the "engine, which sets the bull wheel in motion, then wrap the cable two or three times around the shaft of the "bull wheel, with a man grasping the loose end of the cable, and tighten the wraps around the bull wheel "shaft when the tools will be raised. When the bit is about a foot from the ground suddenly loosen the "grasp of the cable, permitting the tools to drop, and continue in this manner until you have drilled 50ft. or "60ft., by which time the hole will be deep enough to attach the sinker bar and string tools complete. "During the process of spudding, that portion of the cable which is wound around the bull wheel shaft "should be kept wet by pouring water on it, as the great amount of friction is apt to burn the rope unless "this is done.

Sand pump. "After getting all ready to spud, coil the sand pump line on the sand pump reel, carry one end of the "sand pump line up through the sand pump pulley, which is made fast near the top of the derrick, bring it "back down and make fast to the sand pump, and occasionally draw out the tools and run down the sand "pump and remove the dirt, gravel, and broken rock which the bit has passed through. If the hole is dry, "water will have to be put in to mix with the drilling sediment, that it may be removed by the sand pump. "After the hole is sufficiently deep by spudding to admit of the whole string of tools passing below the

Walking beam. "surface of the ground, drilling can be commenced with the walking beam, which, of course, during the "work of spudding has been unused. To accomplish this all the cable must be coiled on the bull wheel "shaft;

" shaft; lower the tools into the well so that they will just touch the bottom of the well, leaving the cable " tight from the weight of the tools; adjust the pitman on the outside end of the walking beam to the crank " attached to the shaft, which passes through the band wheel, which will bring your walking beam in position " for use. Hang the temper screw on the hook at the other end of the walking beam in the derrick, and Temper screw. " attach the clamps of the temper screw to the cable, first having wound the cable where the clamps attach " with some loose hemp or unravelled rope to prevent the clamps from slipping or cutting the cable. The " temper screw being attached to the walking beam, and also to the cable, as the walking beam oscillates " the tools are raised and lowered. Before starting the machinery, unwind about 20ft. of cable off the bull " wheel shaft and let it lie loose on the derrick floor; throw the bull rope off the bull wheel, as it is only " used in taking tools out of the well.

" When tools are to be lowered into the well throw the bull rope off the bull wheel and the heft of the " tools will carry them down, the speed being regulated by a man at the brake over the bull wheel. The " man at the temper screw turns the tools so that the bit falls but once in the same place and lengthens out " the screw as the drilling proceeds. * * *

" Although we have heretofore explained the mode by which the power is utilised, yet to make it more Explanations. " plain we will say the engine, by means of a rubber belt running from the pulley of the engine over the " band wheel, turns the crank attached to the pitman, which is attached to one end of the walking beam, which, " being exactly balanced in a horizontal position on the flat surface of the saddle or centre iron, is fastened to " one end of the sampson post, placed in an upright position, the lower end being morticed into the main " sill and securely keyed and braced. The walking beam oscillating in this position raises and lowers the " tools, as before stated. The tug pulley is fastened to the main shaft by means of flanges, the same as the " band wheel. The bull rope passes over the tug pulley and around the grooved bull wheel, and serves the " same purpose as a belt. As the bull rope turns the bull wheel the cable is wound on the shaft, thus " raising the tools out of the well.

" Our remarks heretofore have been confined to drilling where the rock is found within 10 or 15ft. of the " surface. We will try to explain the mode of procedure when the rock is found 100, 200, or 300ft. below " the surface. In the oil regions the solid rock is found at various depths, from 15 to 300ft. The soil lying " on the top of this rock is generally soft, and sometimes sandy, and it is not an unusual occurrence to find " large boulders in this soil. If in soft and sandy soil no headway could be made by drilling it, as it would " cave in as fast as drilled. To obviate this difficulty 8in. wrought iron drive pipe is driven down to the " solid rock.

" The mode of driving this pipe is follows:— Pipe driving.

" The pipe comes in lengths of about 18ft. and 8in. in diameter, with threads cut on each end. A " driving shoe, with thread cut on inside of one end, and a sharp bevelled edge on the other end, is screwed " on one end of a length of the drive pipe and a driving cap on the other end. Guides are then put " up in the derrick, and a spudding rope wound two or three times around the bull wheel shaft, thence up " over the crown pulley down, and fastened to a block of wood weighing from 800 to 1,500 pounds. Then the " bull rope is adjusted, and the engine being started the spudding rope winds around the bull wheel shaft, a man " grasping the loose end, the same as when spudding a hole, which has been explained before, and in the " same manner, the grasp on the rope is suddenly loosened when the block is raised, say 6ft. or 8ft. above " the driving cap, which allows it to fall with its whole weight upon the driving cap (the piece of drive pipe " having been previously placed through a hole in the centre of the floor of the derrick in an upright position, " the end of the driving shoe resting on the ground below, and the driving cap screwed on the other end, " projecting through the floor up into the derrick). The falling of the block, striking thus upon the capped " end of the drive pipe, forces the shoe to cut the soil, and thus the drive pipe is gradually submerged " beneath the soil, and when one length is driven down about even with the derrick floor the driving cap is " removed and placed on the end of another piece of drive pipe, which is in turn screwed fast to the piece of " pipe already driven, when the process of driving again commences, and so on until completed.

" This pipe must not be driven after the shoe has come in contact with any hard substance harder " than the shoe itself can readily cut, such as boulders or some other exceedingly hard substance, which can " readily be detected from the labor necessary to drive the pipe, or in other words the pipe must not be driven " unless it drives easy. When it becomes hard to drive and but little headway can be made, the tools must " be substituted for the block and proceed to drill ahead of the pipe in the same manner as when spudding " in the conductor hole, and so continuing until the boulder or whatever may be retarding the driving of the " pipe shall have been perforated with the bit, then the driving of the pipe can continue, and in this manner " the solid rock is reached.

" After the drive pipe or conductor pipe is rested on the solid rock, drilling with the 8-inch tools will " continue until after the first sand rock is reached and passed through, as a vein of fresh water is generally " found in this rock. During all this time, drilling will have to be done with more or less water in the hole, " but after the first sand rock is passed, water is seldom found. Then 5⅝ casing is lowered down through " the 8-inch drive pipe, extending down as far as the 8-inch hole is drilled, and there rests upon the rock, " effectually shutting off all the water. Sometimes a few pieces of rope are thrown in, which, washing " round the lower end of the 5⅝ casing, more effectually shuts off the water by working themselves into " the openings.

" When this is done and the water bailed out, the hole is left dry. After having reached this point,

" substitute

" substitute for the large jars, bits, and reamers (smaller ones suitable to pass down through the 5⅝ casing), " and this size is used to completion. After running the length of the screw in ordinary drilling, the tools " are taken out of the well and the hole rimered down; then run the sand pump two or three times down to " remove the sediments.

Sand pump. " The sand pump is sometimes substituted by a bailer or gravel pump, as where there is considerable " water in the hole the sediment can be removed faster. A bit is generally used to drill from one to four " feet; the distance greatly depends upon the nature of the rock to be drilled, whether hard or soft, when it " must be removed and dressed.

Dressing tools. " Dressing a bit means to heat it to about a cherry red, *never to a white heat*, when by the use of a " sledge hammer it is sharpened at its edge, always being dressed to a gauge, in order that the hole may be " kept of one size. As all the steel used in the manufacture of our tools is of the finest English manufacture, " great care should be used in tempering bits and reamers after dressing. They should never be thrown into " a vessel full of water when hot. One and a half inches of water is all that is required. Reamers should " follow the bits nearly as fast as the drilling proceeds, that the hole may be kept round and true, and " thereby obviate the danger of 'flat or crooked holes.'

Rig irons. " The rig irons are used in and around the derrick and rig, and are placed as follows:—

" The large flanges are placed in the centre of the band wheel, one on each side, directly opposite each " other, and fastened with bolts passing through the band wheel. The small flanges are in like manner " fastened to the tug pulley. Through both the band wheel and tug pulley the shaft passes, being keyed in " position when properly adjusted.

Boxes. " The boxes are fastened to a wooden frame and the shaft revolves in them. A crank is fastened to one
Wrist pin and pitman. " end of the shaft by means of a key. The wrist pin is fastened to a crank. The wooden pitman is fastened " to the wrist pin at one end and the upper end attached to the stirrup, which passes over the outer end of " the walking beam. The centre irons and saddle are adjusted on top of the sampson post, and the walking
Crown pulley. " beam is fastened on the saddle. The hook is placed in the end of the walking beam. The crown pulley " is placed in the top of the derrick for the drilling rope to pass over.

Drilling rope. " The drilling cable is generally about as long as the depth of the well is supposed to be drilled. For " instance, where they drill 1,200ft., they have a cable 1,400ft. long, 1¾ diameter, weighing about 1lb. to the " foot.

Bull rope. " The bull rope is about 80ft. long, 2in. in diameter, weighing about 1½lbs. to the foot.

Tube casing. " The tubing line is used for lowering the casing and tubing into the well, and is about 200ft. long " weighing about 1lb. to the foot.

To tube the well. " After the well is drilled to a sufficient depth, the next thing in order is to tube the well, which is done " in the following manner:—

" Screw a casing head on the top joint, of the 5⅝ casing, level with the derrick floor. A piece of perforated " tubing is lowered down through the mouth of the 5⅝ casing, then adjust tubing elevators under the collar " of the first joint of tubing, and to this screw the working barrel with the standing valves in the lower end, " then add joints of tubing until a sufficient number of lengths have been added to reach the bottom of the " well. Then screw the upper valve of the working barrel to the valve rod, and to the valve rod screw " sufficient length of sucker rods to lower the upper valves of the working barrel down into it in the bottom " of the well. To the top joints of the sucker rods screw the polished rod, which passes up through the " stuffing box (stuffing box having been previously screwed on the top joint of tubing), and is fastened to the " adjuster on one end of the walking beam.

" The walking beam oscillates in the same manner as when drilling, and raises and lowers the sucker " rods and works the valves below, raising the fluid.

Engines. " The engine we manufacture we wish to call your particular attention to. These engines are " particularly adapted to drilling and pumping oil or artesian wells, having the reversible attachment, by " means of which the engine may be reversed by the driller when in the derrick, placed usually about " 50ft. from the engine. This is done by means of a cord running from the loop of the reversible attach- " ment of the engine into the derrick. By pulling the cord the engine is reversed, causing it to change its " motion and run in the contrary direction.

" This engine is indispensable in drilling or pumping oil or artesian wells.

" The engine running one way lowers the tools into the well and by being reversed takes the tools out " of the well.

Boilers. " Our boilers are of the square fire box pattern, portable, and are first-class in every particular.

" AMES & KEESE MANUFACTURING CO.

" Titusville and Corry., Penn'a."

Prices. The prices of the various items composing a drilling plant are as under, f.o.b. the cars at the works:—

Auger stems, 20ft. long to 30ft. long, from 2in. to 3½in. diameter, cost from	$32 to $80	each
Sinker bars, 6ft. long to 18ft. long, from 2in. diameter to 3½in. diameter, cost from	$21 to $55	"
Bits, 3½in. to 8in. in width, and pointed with steel, weighing from 20lbs. to 80lbs. each, cost from	$18 to $45	" Round

Round reamers, from	$20 to $45 each
Steel drill jars, to drill holes from 3½in. to 8in., cost from	$70 to $150 " according to size
Temper screws	$50 each.
Rope sockets	$17 "
Wrenches	$12 "
Sand pumps vary very much; the sizes are from 2in. to 5in. diameter, and cost from	$18 to $33 each
The horn socket	$30 "
Slip socket	$85 to $125 "
Grabs	$45 to $75 "
Rope	$20 "
Winged substitute	$90 "
Hollow reamers	$85 to $160 "
Hooks	$15 to $30 "
Star reamers	$45 to $75 "
Slip spear	$35 to $45 "
Rope knife	$10 "
Swivels	$14 "

Manufacturers' Price List of Wrought Iron Artesian Well Tubing, with screw and socket or flush joints.

Wrought-iron tubing.

Inside diameter.	Price per foot.	Inside diameter.	Price per foot.
1¼	$0·16	4½	$0·86
1½	0·20	5	1·05
2	0·27	6	1·40
2½	0·34	7	1·90
3	0·45	8	2·25
3½	0·57	9	3·00
4	0·72	10	4·00

Prices f.o.b. cars at works.

Subject to fluctuation in price of iron.

Lining pipe about the same relative prices per foot lineal.

As far as I was able to ascertain, the best makers of artesian well drilling plant in America are Messrs. Ames & Keese, successors to Messrs. Gibbs & Sterrett, Titusville and Corry, Pennsylvania.

Best makers.

A plant sufficient to sink a hole 1,000ft. deep would cost, f.o.b. the cars at the works, £2,000.

Cost of plant to sink 1,000ft.

Item No. 34.—WINDMILLS FOR PUMPS, &c.

Windmills are commonly used for pumping water for railway station purposes in the United States, and I have obtained particulars of the best kind of windmills used for this work.

Andrew Corcoran's Windmills.

Corcoran's solid wheel windmills.

These windmills have what are known as "solid wheels," and the power is transmitted direct to the pump by a balance connection marked in the illustrations (Plate No. 105) 4, 1, 10, 12, 24, and D, thus working independently, while the adjustable side vane N, and flexible rudder vane M, with the compensating lever 26, combine in producing a self-regulating movement. In this way the wind wheel, I, J, K, is guided with accuracy and precision. The wind is by this mechanism made a governor as well as a propeller. The mill is made of wrought and malleable cast iron, the whole central working being in the main frame. No. 1 is a piece of wrought-iron tubing, with its bearing cast on it, resting and turning on an anti-friction washer, No. 17. The tube is prolonged through No. 17 to a step, No. 18, and is firmly held by the collar, No. 16, at the bottom of the tube No. 1. The wrist pins, Nos. 30 and 31, are of steel, as well as the main shaft and pitman, No. 24. They work in bearings lined with Babbitt metal. It is claimed by the inventor that this is the only mill that will stand the violent gales of the sea-coast without being taken down in winter, and that it develops more power by 50 per cent. than any other windmill having the same diameter of wheel.

Plate No. 105. Description.

Materials used.

Tube.

Wrist pins.

Advantages claimed.

The following is a list of the prices of the improved self-regulating windmills made by A. J. Corcoran, of New York, at the works:—

List of prices for windmills without pumps at the works.

No.	Diameter. feet.	Weight. lbs.	Price. $
1	8½	450	95
2	10	600	120
3	12	850	150
4	14	1,160	250
5	16	1,400	375
6	18	1,900	450
7	20	2,400	600
8	25	2,800	775
9	30	3,700	975

With trade discount.

These prices are for the windmill complete, with 30ft. of pitman, stop rod and lever, but exclusive of pump.

The following tables show the class and proper diameters of pumps in inches, to use with Corcoran's windmills; also the quantity of water in gallons that these mills will pump for elevations from 10ft. to 200ft.

Sizes of pumps to use with the windmills.

TABLE I.—Showing the Class and Proper Diameter, in inches, of Pumps in use with A. J. Corcoran's Windmills, suitable for different elevations and based upon actual running results.

Designation of Mill.	Elevation in feet to which water is to be raised—from 10ft. to 200ft.																																												
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200
8½-ft. Wheel ..	Fig. 6	6	6	6	6	6	6	6	6																																
	4½	4	3½	3¼	3	2¾	2½	2¼	2																														
10-ft. Wheel ..	Fig. 12	12	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6																				
	4¾	3¾	4¾	4¼	3½	3½	3¼	3¼	3	2¾	2¾	2¾	2½	2½	2¼	2¼	2¼	2¼	2																			
12-ft. Wheel ..	Fig. 82	12	12	12	6	6	6	6	6	6	6	6	6	6	6	6	6	21	21	21	21	21	21	21	21	21	21	21	21										
	6¼	5	4½	4	5	4¾	4½	4¼	4	3¾	3½	3½	3¼	3¼	3	3	3	2¾	2¾	2¾	2¾	2½	2½	2½	2½	2½	2½	2¼	2¼										
14-ft. Wheel ..	Fig. 82	12	12	12	12	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
	6¾	5½	4¾	4¼	3¾	5	4¾	4½	4¼	4	3¾	3¾	3½	3½	3¼	3¼	3¼	3	3	3	2¾	2¾	2¾	2¾	2½	2½	2½	2½	2½	2½	2¼	2¼	2¼	2¼	2¼	2¼	2	2
16-ft. Wheel ..	Fig. 82	82	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	6	6	6	6	6	6	6	6	6	21	21	21	21	21	21	21	21	21	21	21
	7¾	6½	5½	5	4½	4¼	4	3¾	3½	3¼	3¼	3	3	2¾	2¾	2¾	2½	2½	2½	3½	3¼	3¼	3¼	3¼	3	3	3	3	2¾	2¾	2¾	2¾	2¾	2¾	2½	2½	2½	2½	2½
18-ft. Wheel ..	Fig. 82	82	82	82	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	6	6
	10½	8½	7½	6½	6	5½	5¼	5	4¾	4½	4¼	4	4	3¾	3¾	3½	3½	3¼	3¼	3¼	3¼	3	3	3	3	2¾	2¾	2¾	2¾	2¾	2½	2½	2½	2½	2½	2½	2½	3¼	3¼
20-ft. Wheel ..	Fig. 82	82	82	82	82	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	11¼	9¼	8	7	6½	6	5½	5¼	5	4¾	4½	4¼	4	4	3¾	3¾	3½	3¾	3½	3½	3¼	3¼	3¼	3¼	3	3	3	3	2¾	2¾	2¾	2¾	2¾	2¾	2½	2½	2½	2½	2½
25-ft. Wheel ..	Fig. 82	82	82	82	82	82	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	12¼	10	8¾	7¾	7	6½	6	5¾	5½	5¼	5	4¾	4¾	4½	4¼	4¼	4	4	3¾	3¾	3¾	3½	3½	3½	3½	3¼	3¼	3¼	3¼	3	3	3	3	3	3	2¾	2¾	2¾	2¾
30-ft. Wheel ..	Fig. 82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	19	15½	13½	12	11	10¼	9½	9	8½	8	7¾	7½	7¼	7	6¾	6½	6¼	6¼	6	5¾	5¾	5½	5½	5¼	5¼	5¼	5	5	5	4¾	4¾	4½	4½	4½	4½	4¼	4¼	4¼	4¼

Pump Figure 6, referred to above, is a single-acting suction and force pump.
" 12, " " is a double-acting suction and force pump.
Pump Figure 21, referred to above, is a single-acting submerged pump.
" 82, " " is a double-acting suction and force pump.

TABLE II.—Giving Quantity in Gallons of Water that A. J. Corcoran's Improved Storm-defying Windmill will Pump per Minute for Elevations of from 10ft. to 200ft.

Designation of Mill.	Vertical distance from where water is obtained to point of delivery.							
	10ft.	15ft.	25ft.	50ft.	75ft.	100ft.	150ft.	200ft.
8½-ft. Wheel	15,242	10,162	6,162	3,016				
10-ft. Wheel	48,262	32,175	19,179	9,563	6,638	4,250		
12-ft. Wheel	86,708	57,805	33,941	17,952	11,851	8,485	5,680	
14-ft. Wheel	111,665	74,443	45,139	22,569	15,304	11,246	7,807	4,998
16-ft. Wheel	155,982	103,988	64,600	31,654	19,542	16,150	9,771	8,075
18-ft. Wheel	249,930	159,954	97,682	52,165	32,513	24,421	17,485	12,211
20-ft. Wheel	309,604	206,403	124,950	63,750	40,800	31,248	19,284	15,938
25-ft. Wheel	532,517	355,012	212,381	106,964	71,604	49,725	37,349	26,741
30-ft. Wheel	1,080,112	728,828	430,848	216,172	146,608	107,712	74,800	54,043

"Eclipse"

"Eclipse" Windmill.

"Eclipse" windmill.

Mr. Corcoran, of New York, also controls the export trade of the "Eclipse" windmill, which is also a solid wheel mill, and is self-regulating. The "Eclipse" mill is largely used for railway purposes. A 20ft. diameter mill driving a 5in. x 12in. pump will pump sufficient water to supply from twenty to thirty locomotive engines per diem. These mills are used on many of the important railroads in the States, such as the Union Pacific, Central Pacific, Southern Pacific, Chicago and North-Western, Denver and Rio Grande, and Illinois Central Railroads.

The United States Wind Engine and Pump Company, Batavia, Illinois.

Halladay sectional windmill.

The mill made by this company is that known as the "Halladay" windmill. It is a "sectional" wheel mill, and is governed by the centrifugal force of the wheel. It is steady and uniform in its action. The inventor argues that "sectional" wheels are safer in storms than solid wheels, and points to the fact that some of these wheels, 60ft. in diameter, have been running successfully for years, whereas the practical limit in diameter of a solid wheel mill is about 30ft. Many of these mills are used by the Pennsylvania Railroad Company, the Central Pacific, the Chicago and North-Western, New York and Lake Erie, the Denver and Rio Grande Railway, and several other lines in the States.

Prices f.o.b. Boston, exclusive of pumps.

The mills are supplied at the following prices f.o.b. New York or Boston (packing extra):—

Number.	Diameter.	Weight.	Price.
	ft.	lbs.	$
5	14	1,440	200
6	16	1,895	280
7	18	2,025	325
8	20	2,500	375
8½	22	2,820	425
9	25	3,500	500
9½	28	3,720	550
10	30	3,866	575

With trade discounts, exclusive of pumps, air chamber, or piping.

The pumps are double-acting, and particulars will be found in the following table:—

Power of pumps.

Pumps.

Description.	Diameter cylinder, in inches.	Stroke in inches.	Number of strokes per minute.*	Water discharged per minute in gallons.	Price.	
					Iron barrel.	Brass lined.
					$	$
Power pump	4	12	100	65	55	62
"	5	12	84	86	75	83
"	5	15	84	107	80	90
"	6	18	80	176	125	140

* Maximum speed. Two strokes each revolution.

Air Chambers.	Price.
For a 4in. x 12in. pump	$8
" 5in. x 15in. "	$10
" 6in. x 18in. "	$12·50

Valve seats, stems, and stuffing boxes of brass, and all parts interchangeable (packing extra).

As the power to drive windmills for pumping water costs nothing, and the only outlay is the first cost, interest, and wear and tear of the machinery, which is not very heavy, I would recommend two being purchased for trial, one being of the solid wheel form, and the other of the sectional wheel form, to be used in lieu of steam power at Kadina and Green's Plains respectively.

Item No. 35.—AND ANY OTHER SUBJECTS THAT MAY BE OF INTEREST AND USEFUL IN THE COLONY AS REGARDS RAILWAYS OR PUBLIC WORKS WITH WHICH YOU ARE CONNECTED.

Having already alluded to various subjects of interest not specially indicated in my letter of instructions, and the compilation of this report having occupied more time than I anticipated, I must defer the description of many other objects which came under my notice during my tour until a more favorable opportunity occurs, but will conclude this report by describing one or two interesting subjects under the following heading:—

Miscellaneous Items.

MAIL-BAG PICKING UP AND DELIVERY APPARATUS, AS USED ON ENGLISH RAILWAYS.

Picking up and delivering mails.

Plates Nos. 106, 107, and 108 represent the system adopted for picking up and delivering mails by the fast trains on the English Railways. Plate

Plate No. 106. Stationary apparatus. Plate No. 106 illustrates the stationary apparatus fixed on the line from which the mail-bags are taken up by the passing trains.

Plate No. 107. Carriage delivery apparatus. Plate No. 107 illustrates the mail-bag delivery apparatus attached to the carriage, by which the bags are delivered from the carriage when in motion into the stationary apparatus shown on Plate No. 108.

Working drawings. I have obtained a full set of working drawings of the whole arrangement, but the above illustrations will suffice to show the principle, which differs very materially from that used on the American Railways, and illustrated in Plate No. 22 and described on page 14.

HEIGHTS AND PROJECTIONS OF PLATFORMS ON ENGLISH RAILWAYS.

Plate No. 109. Heights of platforms English Railways. Plate No. 109 illustrates the various heights and projections of the coping of the passenger platforms on the principal railways in England. In America passenger platforms are not raised above the ground to a greater extent than from 6 or 8in. to 12 or 14in.

STEEL TIRES, AXLES, WHEELS, &c.

Tires and axles. I visited the principal steel works in England where tires and axles are made, as well as the locomotive works at Crewe, Doncaster, and Derby, and I append a list of the best manufacturers of steel tires and axles, and the description of steel from which they are made.

List of Manufacturers of Steel Tires and Axles, and the Process adopted by each firm.

Name of Manufacturer.	Usual Process of Manufacture adopted.
Vickers, Sons, & Co., Sheffield	Siemens-Martin only.
Taylor Bros., Leeds	Siemens-Martin and Crucible Cast Steel.
Monkbridge Iron Co., Leeds	Siemens-Martin only (crucible furnaces out of work).
Chas. Cammell, & Co., Sheffield	Bessemer, Siemens-Martin, and Crucible Cast Steel.
Landore Siemens Steel Co., Landore	Siemens-Martin only.
Patent Shaft Co., Wednesbury	Bessemer and Siemens-Martin; the latter in small quantities.
John Brown & Co., Sheffield	Bessemer only.
H. Bessemer & Co., Sheffield	Bessemer only.
Brown, Bailey, Dixon, & Co., Sheffield	Bessemer only.
Bolton Iron and Steel Co., Bolton, Lanc.	Bessemer only.
Blaenavon Iron and Steel Co., Blaenavon, Mon.	Bessemer only.
Fried, Krupp, 9, New Broad-street, E.C.	Bessemer, Siemens-Martin, and Crucible Cast Steel.

The following qualities and tests for steel tires are adopted by the various railway companies named:—

Indian Railways.

Tests.

Name of Railway.	Tires used.	Tests specified.
Indian State Railways	Bessemer.	20cwt. falling from 10ft. and upwards, until deflection amounts to ⅛th of diameter of tire on tread. Tensile strength, 45 tons per square inch. Reduction in area, 20 per cent.
	Engine tires.	Quality not exactly specified, but must be approved by engineer. Drop tests as per Bessemer. Tensile strength 45 tons per square inch. Elongation not specified.
Madras Railway	Bessemer.	Drop test—One ton falling upon tire until deflected 2in. for every foot of internal diameter No tensile test specified.
	Engine tires, Crucible Cast Steel.	Drop test as above for Bessemer tires. Tensile test 40 tons, lately increased to 47 tons per square inch. Elongation and reduction in area not specified.
East Indian Railways	Bessemer.	Tests same as for Indian State Railways.
Eastern Bengal Railway	Bessemer.	Tests same as for Madras Railway.
Scinde, Punjaub, and Delhi Railway	Bessemer.	Test—One ton falling from 2ft. to 4ft. to 6ft. to 8ft., &c., until deflected 9in. without fracture. Tensile strength 35 tons per square inch, and as much above that amount as is consistent with a reduction in area of 40 per cent.
Oude and Rohilkund Railway	Siemens or Crucible only.	Test—One ton falling from 5ft. to 10ft. to 15ft., &c., until deflection amounts to 2in. per foot of diameter. Tensile strength 45 tons per square inch. Elongation 20 per cent, Woolwich standard test pieces to be used; and be capable of bending double when cold without fracture.

Cape

Name of Railway.	Tires used.	Tests specified.
Cape Railways	Bessemer.	Test—One ton falling 8ft., repeated blows, until tire is deflected ⅛th of its diameter without fracture. Tensile strength not less than 37 tons nor more than 40 tons per square inch, with a reduction in area of not less than 20 per cent. and not more than 30 per cent.
	Cast steel tires, Crucible.	Test—One ton falling from 5ft. to 10ft. to 15ft., &c., until the tire has deflected 2in. per foot of internal diameter without fracture. Tensile strength not less than 48 tons per square inch. No reduction in area or elongation specified.
Great Indian Peninsula Railway	Either Bessemer, Siemens, or Crucible, or other steel, the manufacturer to state which he proposes to supply.	Tensile test not less than 42 tons per square inch. Elongation, 12½ per cent. in a 2in. test piece, 0·565 area. Each tire must be tested by dropping it from the following heights on to a rail fastened on the top of an ingot of steel or iron, at least 2 tons in weight, the tire being afterwards turned 90° and dropped again in a similar manner, viz :— Height of drop. For 3ft. 6in. diam. tires, and under .....5ft. From " " " to 4ft. 6in.....4ft. " 4ft. 6in. " " to 5ft. 6in. ....3ft. 6in. Above 5ft. 6in.....3ft. One tire out of each charge must be further tested under the drop, being placed on a 2-ton block, and a tup of 1 ton falling upon it from a height of 30ft, until fracture commences.

English Railways.

TIRES.

Name of Railway.	Tires used.	Tests specified.
Great Western Railway	Bessemer and Siemens, no Crucible used.	Test.—To be compressed by hydraulic pressure to extent of 1in. to every 10in. of external diameter of tire, without fracture. The compression to be continued until the tire is broken. Tensile strength not less than 40 tons per square inch. Elongation, 25 per cent. Any tire failing before having run twelve months to be replaced at expense of contractor.
South-Eastern Railway	Bessemer for tenders, Crucible or Siemens for engines.	Obtained from best makers, and no tests imposed by locomotive department.
	Bessemer for carriages and wagons.	To be manufactured from ~~85~~ 25 per cent. of best Swedish charcoal iron, and 75 per cent. of best selected English hammered iron. To stand without fracture under hydraulic pressure, 1½in. compression for each foot of external diameter.
London, Chatham, and Dover Railway	Vickers, Siemens-Martin's for engine tires. Bessemer, made by Chas. Cammell & Co., John Brown & Co., and the Bolton Iron and Steel Company for carriages and wagons. Siemens tires made by Landore Siemens Steel Company are also used for carriages.	No tests imposed, but experiments are made by hydraulic pressure on tires supplied by various firms, and for tensile strength the firms whose material gives the best results are selected as contractors for future supplies.

Name of Railway.	Tires used.	Tests specified.
London and South-Western Railway	Bessemer (for wagons) made by Patent Shaft, Bolton Iron Co., John Brown & Co., Cammell and Co., Brown, Bailey, Dixon, and Co., and Henry Bessemer.	Test—To stand without fracture the test of being pressed cold into an oval shape by hydraulic power, and to bear 2in. of compression for every foot of external diameter.
	Crucible Cast Steel for engines and tenders, by Vickers & Sons, F. Krupp, or Cammell and Co.	Tests same as for Bessemer tires.
Great Eastern Railway.....	Bessemer for wagons and carriages and recently for engines. Formerly crucible tires were specified for engines.	Tests same as on the London and South-Western Railway.
Midland Railway	Bessemer for carriages and wagons, Siemens and Monkbridge tires are also used.	Test—To have a compression of 4in. by hydraulic pressure for 3ft. diameter, and 5in. for 3ft. 6in. diameter tires.
		This compression to be continued till the tire is broken or doubled up. Tensile strain not less than 40 tons per square inch with 25 per cent. elongation. If tire fails before running 12 months, it must be replaced by contractors at expense of manufacturer.
	Siemens or Crucible for engines and tenders by Vickers, Son, & Co., Monkbridge Iron Co., Cammell & Co., Taylor Bros. & Co.	Test—To stand 3in. deflection per foot of diameter under the drop, and have a tensile strain of 45 tons per square inch.
London, Brighton, and South-coast Railway	Crucible Cast Steel for engines and carriages	Obtained from best makers of known and approved quality, but no tests are imposed. The tires generally have a tensile strength of 45 tons per square inch.
Great Northern Railway	Crucible Steel for engines by Monkbridge Iron Co., and Taylor Bros.	No tests specified.
	Bessemer for carriages, and wagons and tender tires, by Bessemer and Co., John Brown and Co., Chs. Cammell and Co., and Brown, Bailey, & Dixon	No tests specified.
London and North-Western Railway	Bessemer for tenders, carriages, and wagons, or Siemens-Martin for driving wheels. Engine wheels recently made of cast steel at Crewe works.	All prepared from best material and every casting is tested, but no further tests are made with finished tires.

AXLES.

Name of Railway.	Straight Axles.	Crank Axles.	Tests.
Great Western Railway..	For carriages, wagons, and engines, are made at Swindon, forged under the hammer from billets.	Made at Swindon, forged under the hammer from best wrought iron scrap. Lately Bessemer steel has been extensively used.	—

South-

Name of Railway.	Straight Axles.	Crank Axles.	Tests.
South-Eastern Railway ..	For engines and tenders, of Bessemer steel, from the best makers. For carriages, of Bessemer steel of 25 per cent. best Swedish iron, and 75 per cent. best English hæmatite.	Crucible cast steel, from the best makers.	Test—To stand five blows from a weight of 2,000lbs. falling from a height of 20ft., upon the axle, upon supports 3ft. 6in. apart, the axle being reversed after each blow.
London, Brighton, and South Coast Railway	For carriages, of Monkridge Company's iron. For engines, crucible cast steel.	Crucible cast steel, from best makers.	No tests specified.
London, Chatham, and Dover Railway	For wagons, Patent Shaft Company's best Staffordshire iron, or Cammell & Co.'s and John Brown's Bessemer steel. For engines and carriages, Vickers and Sons cast steel, and best Yorkshire iron.	Vickers & Sons cast steel; also best Yorkshire iron.	Test—All straight axles to be tested under the drop, and must stand to be doubled up cold without signs of fracture.
Great Northern Railway ..	For carriages and wagons, of Bessemer steel, by H. Bessemer and Co., John Brown & Co., Chas. Cammell & Co., and Brown, Bayley, & Dixon's manufacture. For engines, of best Yorkshire iron, obtained from best Yorkshire houses.	Best Yorkshire iron, obtained from the best Yorkshire houses.	No tests specified.
Midland Railway	For carriages and wagons, of Bessemer steel. For engines and tenders, principally of best Yorkshire iron of Lowmoor, Taylor's, Monkbridge, or Cooper's manufacture.	Best Yorkshire iron of Taylor's, Monkbridge, or Cooper's make. Vickers or Cammell's cast steel is also used.	Test—Same as South-Eastern Railway Company, but the tests are continued until the axle breaks. Tensile strain not less than 40 tons per square inch, elongation 25 per cent. Straight axles for engines to be bent double when cold without signs of fracture. Crank axles are expected to run 200,000 miles.
London and North-Western Railway	For engines, tenders, carriages, and wagons, of Bessemer steel, made at Crewe.	Crank axles, of Bessemer steel, made at Crewe.	Test—Each cast is tested for quality of carbon.
Great Eastern Railway ..	For carriages and wagons, "Best Bessemer steel."	Crucible steel.	Test—One axle out of fifty to be tested under the drop on bearings 3ft. 6in. apart, with a weight of 2,000lbs. falling from a height of 20ft., and the axle is to stand five such blows without fracture, being reversed after each blow. For crank axles no special test.

STEEL RAILS AND THE TESTS USUALLY SPECIFIED.

Difference of opinion among engineers as to tests.

This is a subject which has occupied a great amount of attention, not only on the Continent of Europe and in England, but also in America, and it is surprising to note the great difference of opinion prevailing among engineers as to the modes to be adopted for inspection and testing of steel rails. Among the engineers who have taken great interest, and have made innumerable experiments on this subject, may be

Mr. Sandberg's inquiries and experience.

mentioned Mr. Price Williams, Mr. Joseph T. Smith, and Mr. Sandberg, C.E., inspector to the Swedish Government, who has written extensively, and has from time to time published the results of his researches. Mr. Sandberg, I believe, has had as much experience in rail inspection as any other engineer with whom I am acquainted, and I cannot do better than give, in as condensed form as possible, his opinions and recommendations. Mr. Sandberg's inquiries and experiments have chiefly been confined to the "Vignolles'" or flange-bottomed section of rails, which are used in nearly every country except England, and as that is the class of rail used in this colony, and as I have for years adopted sections of rails for the South Australian Railways which approximate very closely to Mr. Sandberg's standards, any remarks made by him will be the more interesting. With regard to the mode of manufacture, Mr. Sandberg's practice is to allow the maker to choose his own method, so long as the inspector sees that the rails are sound and correct in every exterior part, and he affirms that a competent, independent, and strict supervision of the daily make, testing the quality, as well as passing the rails, and finally stamping and approving by certificate before the rails leave the works, and are paid for, constitutes a good inspection. It is the practice in some parts of Europe, notably in Germany, to approve rails at the works, and to repeat the tests and inspection on their arrival at their destination, and if the two do not agree, to reject the rails. Mr. Sandberg very justly says that such a system is very unfair to the manufacturer. He also records his opinion that specifications for rails are becoming overdone; in America chemically, with the stipulation of only one certain chemical composition in the rails. and in Germany physically, in laying too much stress upon contraction of area in fractured samples to test the tensile strength. Mr. Sandberg's method of inspection is substantially as follows:—

Sandberg's sections used in South Australia.

Mode of manufacture and inspection.

What constitutes good inspection.

Practice in Germany.

Specifications impose too high a standard of chemical and physical tests.

Method of inspection adopted by Mr. Sandberg.

Inspection-book.

Templates, measurements, gauging, and stamping.

Weighing and allowance.

Crop ends tested daily.

Inspection after rails are rolled.

The specification for the rails is entered in the inspection-book, which the assistant has to keep as a record of the daily work, both regarding rejected and accepted rails. Before commencing to roll any rails the template is first approved, the lengths to which the rails are to be cut off measured exactly with a standard steel rule, and the gauges checked and stamped, such as the female gauge for sections, others for drilling the fishbolt holes, &c. As soon as the first bars leave the rolls they are weighed, ten of them being weighed to see whether they correspond with the specified weight with the usual allowance of 2 per cent. on single rails and 1 per cent. upon the whole order. The crop ends are, immediately after they cool, tested with the falling weight, and, if they are not strong enough, the material is altered so as to sustain the proper test. The inspection of the rail really begins as soon as any of them are ready, straightened and drilled—first, by measuring the length; secondly, by determining whether they are straight; thirdly, by examining them for flaws, cracks, or imperfections; fourthly, by gauging the fishbolt holes; and, finally, by stamping each rail with the inspector's mark and initials on the end of each rail.

Entering number of accepted and rejected rails in inspection book.

Daily result of work sent to head office.

No duplicate certificates issued.

The next process is to count up the number of rails of the different lengths, and to enter the accepted rails on the right-hand side of the inspection-book and the rejected rails on the left-hand side in the proper columns arranged for the purpose (bad ends, too long, too short, crooked, twisted, badly drilled, &c.). The rails that are rejected may be taken away to be altered and may again come before the inspector for his approval or rejection. The result of each day's work is sent by the inspector to the engineer's head office, and after each 1,000 tons are made the original inspection book is also sent. This is copied, and a copy sent to the railway company or other employers for their information. The original book with all the documents are retained and kept in the engineer's office, and when the rails are shipped a certificate of inspection is issued against the copy of the bill of lading. No duplicate certificates are ever issued. As soon as the order is completed the results of the rejection are entered in a book at the engineer's office, and at the end of the year all the orders are tabulated and conclusions drawn from a comparison of the results.

Tests imposed by German engineers.

Extract from German specification.

Tests.

Tensile strength 81lbs. to square inch.

Contraction, 35 per cent.

With regard to testing, the German engineers have imposed such extreme tests for the steel rails that are produced in that country that would not be submitted to by any manufacturer out of Germany, as for example:—"The rail must be placed on its flange, and must receive, without cracking or breaking, a "curvature of $\frac{1}{10}$ of its free-lying length; also of 50mm. with the bearing 1m. apart. With increased "loading the fracture must not occur suddenly. With a deadweight of 15,000 kilos on the middle between "bearings 1m. apart there must be no permanent set after the weight has been on several hours. The rail "must allow of being bent permanently sideways, while cold, to a radius of 50 metres; also, when thrown "from a height of 2 metres upon a hard surface the rail must suffer no damage. The fracture must show a "homogeneous texture, and the material must possess a cohesion of 5,700 kilos per square cm. (81·070 "pounds per square inch), and a contraction at the point of fracture of at least 35 per cent. The maker "must also, within ten years from the date of laying down the rails for traffic, replace all rails which break "or show defects such as in the opinion of the officer of the company would render them unserviceable in "consequence of traffic, but not of accidents or collisions." The replacement to be under specified conditions as to payment for new rails and valuing the old ones. The contractor must also deposit 5 per cent. on the amount of the contract as security.

German makers turn out excellent rails.

"Straightening" principal cause of rejection.

With regard to German makers of rails, Mr. Sandberg's experience is, that if they work under the usual simple specifications, they are quite competent to do justice under ordinary conditions, and that during the last two or three years his experience has been that the inspection results are very good, the principal cause of rejection there being, as it is in England, the results of straightening. He also remarks upon the necessity for

for more complete data respecting the relationship existing between temperature and test, as a more severe falling test is required for rails made for cold climates than for those required for warm ones. (Sandberg's paper on Rail Inspection, 1880.)

More severe tests required for cold climates.

The average specifications drawn by engineers in England fix very high tests for steel rails. They stipulate the quality of the pig iron used, the class of hematite with which it shall be mixed, and that the best Rhenish speigel—with not less than 10 per cent. of charcoal—pigs shall be re-melted in an air furnace; that the ingots shall be hammered, not bloomed, and then tested with a heavy falling test, such as for instance, rails should be bent to a right angle by blows without breaking. The rails must also be chemically tested by a professional analyst, and finally after drilling, made warm and dipped in hot linseed oil. All these restrictions really mean that the rail consumer must pay an extra price with no great corresponding advantage.

English rail specifications.

Composition of metal.

Chemical test.

Mr. Sandberg's three tests for steel rails are, one for stiffness and dead load, one for quality and wearing capacity, and one falling test for safety against breakage. These tests are applied in strict accordance with the weight of the rail specified.

Mr. Sandberg's three tests.

For iron rails he uses a ball, the weight of which in hundredweights must be multiplied by the height of the fall in feet, to equal the weight of the rail in pounds per yard. For an iron rail 56lbs. per yard he prescribes a 7cwt. ball falling 8ft. on the rail supported on bearings 3ft. apart. The effect of this blow should give a deflection of ¾in. to 1in., and if that is not the result, there is some fundamental fault. The fall must then be increased, so as to give the deflection in one blow. He tests for safety by a daily testing of the crop ends, which usually give double the deflection of long rails.

For iron rails.

For steel rails, Mr. Sandberg adopts four or five times the blow that he specifies for iron, viz., a ton falling 20ft. for a 60lb. rail and upwards, and falling 15ft. for a 56lb. rail, with a deflection of three to four inches, according to the hardness of the steel.

For steel rails.

He does not stipulate the mode of manufacture, either in Bessemer, Siemens, or even the Thomas steel, so long as the result obtained by the above testing shows strength, solid fracture, and correct exterior. But he also adopts a valuable test in addition to the above, viz., each inspector has to superintend the mechanical hammering out of a sample ingot into a bar 1in. by ½in., which must stand bending at right angles when cold, and one end of the bar, being nicked and dipped into water, must be then broken to expose the fracture. The corresponding blow of metal in the Bessemer converter must in each case be approved by the foreman of the works before the ingots are taken to the rail mill. Should the steel break, the cast from which it was made must not be used, and the metal must be changed. In such a case as this, a chemical analysis is made, to discover the cause of the brittleness of the metal. The neglect of this mechanical test on every cast made from the converter may result in the rejection of a large quantity of rails. It is of the utmost importance, therefore, to insist on this daily test. After the breaking test has been applied to the rail, the half of the broken piece is then placed on 3ft. bearings, and must stand a blow from a ball weighing *—lbs. falling from a height of *—ft., upon the piece between the supports, without fracture. The bearings are cast iron on oak frames fixed to solid masonry 4ft. deep.

Method of manufacture not stipulated.

Valuable test by hammering into small bar, which is bent and broken.

If test bar not good.

Result of neglecting to test mechanically from sample ingot.

Further testing of pieces of rail broken in first test.

Supports for test rails.

Should one of the rails fail under any of the tests, the lot will be divided into ten equal parts, and one rail from each portion will be tested. Each rail then proving unequal to the test will cause the rejection of the lot. By far the larger number of rejections of rails at the works arise from imperfect straightening, and the process of straightening under presses is not looked upon with much favor by engineers. In America the rails are straightened hot by means of rollers as the rail leaves the cut-off saws. There are three pairs of adjustable vertical rollers, each about 12in. in diameter, all ranged in a row, three on one side bearing upon the bottom rail flange, and the three others on the other side upon the rail head. The camber is taken out by tightening the middle rollers, the rail being carried on horizontal rollers from the hot bench directly through the straightening rollers, in the same position as it leaves the rolls.

If one of test pieces fail.

Hot straightening practised in America.

Straightening rollers.

Mr. Joseph T. Smith, past president of the Iron and Steel Institute, and the manager of the Barrow Hœmatite Iron and Steel Works, in a communication made by him to the Institute of Civil Engineers, gave the records of strength, resistance to wear, and other qualities of Bessemer steel rails made at Barrow for ten years subsequent to 1865, and states that it was found at Barrow, with ordinary care in the selection of materials and in their manipulation, there was no difficulty in producing mild steel possessing a *constant quality;* and that for rails, the best material is steel, having 0·3 per cent of carbon and a tensile strength of thirty-two tons or not varying more than from thirty-one to thirty-three tons. Such rails are absolutely certain, he says, to withstand any shock that can be applied in punching or ordinary wear and they will never fracture under the most severe tup test.

Mr. Jos. T. Smith's remarks on steel for rail-making at Barrow.

Best material is steel having 0·3 per cent. of carbon and a tensile strength of 32 tons.

Experiments made by Mr. Smith at Barrow, tended to indicate that soft steel rails possessed a longer life than those having great hardness. He also records as the result of another experiment, that if worn double-headed steel rails are turned, although the new surface exposed to wear will be as strong as it was when first made, yet the total strength of the rail is lessened by the reduction in area of the lower face, in consequence of the elasticity of the rail being destroyed; but by planing off a thin slice (say one-eighth of an inch), the elasticity can be entirely restored, allowing for a proportionate decrease in the weight of rail due to the wear of the original upper face. Mr. Smith further remarks that the present method of testing rails is wasteful and unsatisfactory, and that from continual experiments made at Barrow, it has been found that if the degree of hardness of a rail can once be absolutely determined, all the other properties required

Mr. Smith's experiments.

Constant wear destroys the elasticity of a rail.

How it can be restored in a double-headed rail.

Present method of testing unsatisfactory.

* These amounts vary with the weight of the rail.

quired in a good rail can be readily calculated. By the use of a registering punching press, an index is obtained of the exact quality of the steel, and the force used to punch the metal increases in a strictly arithmetical progression with the thickness of the metal operated upon. Mr. Smith also has proved by experiment that if the holes under the rails for the fishbolts are first punched with a small punch, and then enlarged to the proper size with a drill, the steel is not injured to any greater extent than if the hole had been drilled only. In conclusion it is well to note that this method of registering the force required to punch the rails, and making that force the basis of the calculation for their other qualities, has been indorsed by the first engineers in England.

Registering punching press.

Rails not injured if the holes for fishbolts are punched small and then drilled.

Edgar Thompson Steel Works, America.

When in America I visited the Edgar Thomson steel rail mills at Bessemer, near Pittsburg, which are generally acknowledged to be the best mills in the United States. The process of manufacture is entirely Bessemer, there being three converters, one of which is always in blast. The usual hydraulic machinery is used for manipulating the ingots during their casting. There are twenty gas producers laid out in blocks of five, seven Siemens' furnaces, and two chimneys 99ft. in height. The ingot furnaces are worked with hydraulic machinery for charging and drawing. The charges are brought on wagons hauled by a locomotive directly from the furnaces, and delivered at the converters without any re-melting, so that an immense saving is effected in the establishment, equal to that of about 500 hands. The ingots after first rolling are cut off to the exact length to make rails 30ft. long (the standard length) by a pair of hydraulic horizontal shears. The rolls for the rails are in three stands of three high rolls 23in. in diameter, driven by a 46in. cylinder engine, having a stroke of 4ft. and a flywheel weighing 50 tons. The blooming rollers are driven by an independent engine, and hydraulic cylinders are used for raising and lowering the feeding platforms, the ingots being mechanically turned over before passing through the rolls; and by the same means the middle roll is moved to alter the sizes. The blooms are lifted upon bogie trucks by an hydraulic crane, and taken to the furnace to be re-heated before going through the rail rolls.

Hot straightening the rails.

As the rails leave the rolls they are carried by means of horizontal rollers driven by the cut-off saw engine to the saw carriage, where both ends are cut off to the standard length required for a 30ft. rail, and after they are cut the rails are carried to the hot straightening plates. As the rail lies upon the rollers it is pressed by forks or fingers worked by hydraulic power against fixed stops arranged in such a manner as to give any degree of curvature required to ensure the rail being straight when it becomes cold. This is a much better plan than that usually adopted of cold straightening by presses and a "gag." The rail, after being passed through the hot straightening rollers, is carried by machinery to the cold straightening presses, and then to the drilling machines. There are also cold saws running at the end of the rail mill to re-trim any rails that may not have been cut to the exact length by the hot saws. The sawing and hot straightening machinery is worked by a man and one boy only, and is the most perfect, simple, and effective arrangement I have seen.

The blowing engines are of the vertical type fixed in two sets of twelve each.

The price for Bessemer steel rails ruling in May last was $40 per ton f.o.b. cars at the works.

Life of Steel Rails.

In the presidential address given by Mr. Jos. T. Smith before the Iron and Steel Institute, he gives some interesting figures, which are worth repeating.

Life of steel rails nine times that of iron.

"One of our members, Mr. Price Williams, has ascertained that up to 1879, 10,194 miles of line had "been laid with steel rails in the United Kingdom, being about one-half of the whole, and as he found that "the average life of a steel rail was *cæteris paribus* just nine times that of an iron rail, he concluded "that the annual saving resulting from the adoption of steel on these 10,194 miles was not less than "£891,100, or, in round figures, about £90 per mile per annum.

"If we assume, as we fairly may, that about one-half of the railway mileage of the world is now laid "with steel rails, it would follow, adopting Mr. Price Williams' figures touching their maximum life, that "the annual economy hence resulting would exceed the incredible sum of £10,000,000 sterling. But it "must not be forgotten that we are still without conclusive evidence of the average life of steel rails under "all the various circumstances of their application, and it is to be feared that the maximum of forty-five "years adopted by Mr. Price Williams will be much oftener the exception than the rule."

CONCLUSION.

I returned to Adelaide on the 14th July, 1883, having left San Francisco on the 10th of June after an absence from the colony of seven months and three weeks, during which period I travelled by railway upwards of 7,400 miles, and visited the following works, manufactories, and places, to which no allusion has been made in this report, viz. :—

Messrs. Simpsons', Waterworks Engineers and Founders, Pimlico.
The Woolwich Arsenal, Gun Forging, Testing, &c.
Messrs. Hatfield's Steel Foundry, Sheffield.
Messrs. Vickers, Sons, & Co.'s Steelworks, Sheffield.
Sir John Brown & Co.'s Steelworks, Sheffield.
Messrs. Ibbotson Brothers, & Co.'s Globe Steelworks, Sheffield.
The Monkbridge Iron and Steel Works, Leeds.

Messrs.

Messrs. Sheppard, Hill, & Co.'s Machine Toolworks, Leeds.
The Bradford Steam Motor Tram System.
The Manchester Tram System.
Messrs. Smith & Coventry's Toolworks, Manchester.
The Ashbury Railway Carriage and Wagon Company's Works, Manchester.
The Carriage Works of the Midland Railway, Derby.
The system of Sharpening Files by the Sand Blast at Midland Railway Works, Derby.
Messrs. Handysides' Bridge Building and Ironworks, Derby.
The Locomotive and Carriage Works of the Great Northern Railway at Doncaster.
Messrs. Brown, Marshall, & Co.'s Railway Carriage Works, Birmingham.
Messrs. Tangye Brothers' Iron, Steel, and Machine Toolworks, Smethwick, near Birmingham.
The Locomotive Works of the London and North-Western Railway at Crewe.
The Barrow Ship-building and Steelworks, Barrow.
The Bristol Railway Wagon Works.
The Brooklyn Bridge, United States of America.
Messrs. Wm. Sellars & Co.'s Toolworks, Philadelphia.
The Waterworks, Fairmount Park, Philadelphia.
Messrs. Brill & Co.'s Railway and Tramcar Works, Philadelphia.
Messrs. Goodell & Waters' Woodworking Machine Works, Philadelphia.
Messrs. Cramps' Shipbuilding Yards and Docks, Philadelphia.
Messrs. F. W. Devoe & Co.'s Painters' Colors, Brush, and Varnish Manufactory, New York.
Messrs. Billmayer & Small's Railway Carworks, New York.
The Fitchburg Steam-Engine and Boiler Works.
The Rollestone Company's Steam-Engine and Boiler Works, Fitchburg.
The Fall River Railway Company's steamers *Bristol* and *Pilgrim*.
The Locomotive Works of the Old Colony Railroad, Boston.
The Bank Safe Deposit Vaults, Boston and Chicago.
The Pittsburg Bridge-Building Works, Pittsburg.
Messrs. Metcalf's Tool Steel, and Wire Works, Pittsburg.
Messrs. French & Co.'s Railway Wagon and Car-Spring Manufactory, Pittsburg.
The Westinghouse Engine Company's Works, Pittsburgh.
The Western Union Telegraph Company's Offices and Operating Rooms, Chicago.
The Chicago Waterworks.
Messrs. Bement & Sons' Machine Tools, Chicago.
Messrs. Pratt, Whitney, & Co.'s Machine Tools, Chicago.
Messrs. Crearer & Adams' Hardware, Brass, and Lamp Works, Chicago.
Messrs. Adams & Westlake's Lampworks, Chicago.
The Transfer Steam Railway Ferry Boat *Solano*, and the Docks at Port Costa, California.
The Menlo Park Stud Farm, California.

In concluding this report, I desire to record my acknowledgment of the great obligations due by me to the various railway corporations, officials, private firms, and individuals, as well as to my professional brethren in the countries which I visited, for their many courtesies and their readiness at all times to afford me any information in their power to assist me in carrying out the duties entrusted to me. At the same time, I wish it to be understood that I have availed myself of every accessible source of information in describing and illustrating the various subjects, and I beg to acknowledge my indebtedness to those personal friends who, at considerable inconvenience, placed at my disposal valuable drawings and illustrations from which the plates accompanying this report have been so faithfully reproduced by Mr. Spiller, the Government Printer, and by Mr. Fraser Crawford, the photo-lithographer attached to the Survey Department, to both of whom my thanks are tendered.

I have, &c.,

H. C. MAIS, Engineer-in-Chief, South Australia.

ALPHABETICAL

ALPHABETICAL INDEX.

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W. F. BATHO, Esq., C.E., Chief Engineer.

Patent Shaft and Axletree Co., Wednesbury.

BRIDGE OVER THE RIVER GANGES, AT BENARES:

Oude and Rohilkund Railway.

Side view of main 350ft. span. Steel.

W. F. BATHO, Esq., C.E., Chief Engineer. *Patent Shaft and Axletree Co., Wednesbury.*

BRIDGE OVER THE RIVER GANGES, AT BENARES:

Oude and Rohilkund Railway.

End view of main 350ft. span Steel.

Plate No. 60.

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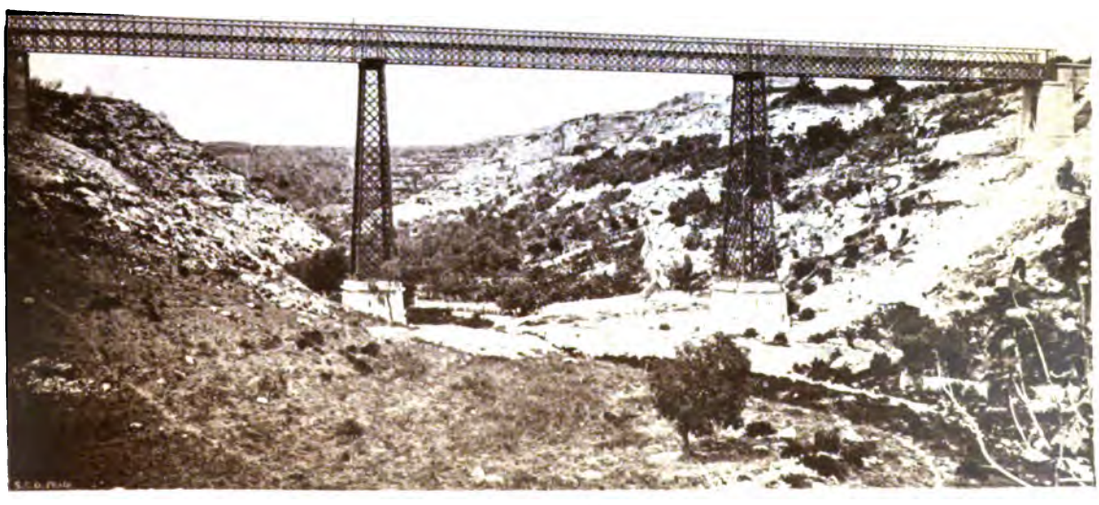
Plate No. 61.

San Stefano Viaduct.

Height, 82 ft. ; length, 416 ft.

Castellaneta Viaduct.

Height, 230 ft. ; length, 673 ft.



Palagianello Viaduct.

Height, 108 ft. ; length, 466 ft.

Plate No. 62.

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MELDON VIADUCT:

North British Railway, England.

Plate No. 63.

Page 61.

BRIDGE OVER THE RIVER DON:

Grand Trunk Railway of Canada.

Constructed by A. HANDYSIDE & CO., Derby.

PARIS BRIDGE:

Grand Trunk Railway of Canada.

Two spans of about 155ft. Width at top, 8ft.; at bottom, 12ft. 8in. Height, 20ft.
To carry one line of rails. Total weight, 503 tons.

Plate No. 64.

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Constructed by HAWKES, CRAYHAY, & CO., Gateshead.

FRASER RIVER BRIDGE:

Canadian Pacific Railway.

315ft. span. 1883

Plate No. 66.

Page 62.

SWING BRIDGE:

Sunderland Docks.

Constructed by the Keystone Bridge Co. 1875.

DRAW BRIDGE OVER RARITAN BAY:

On the New York and Long Branch Railway.

Span, 472ft.

Plate No. 67.

Page 62.

Hon. A. BLEECKER BANKS, President.
ALFRED P. BOLLER, Chief Engineer.
C. L. COOKE, Principal Assistant Engineer.

Designed and constructed by CLARKE, REEVES, & CO., Phœnixville, Pa.
Smith & McGaw, sub-contractors for foundations and masonry.

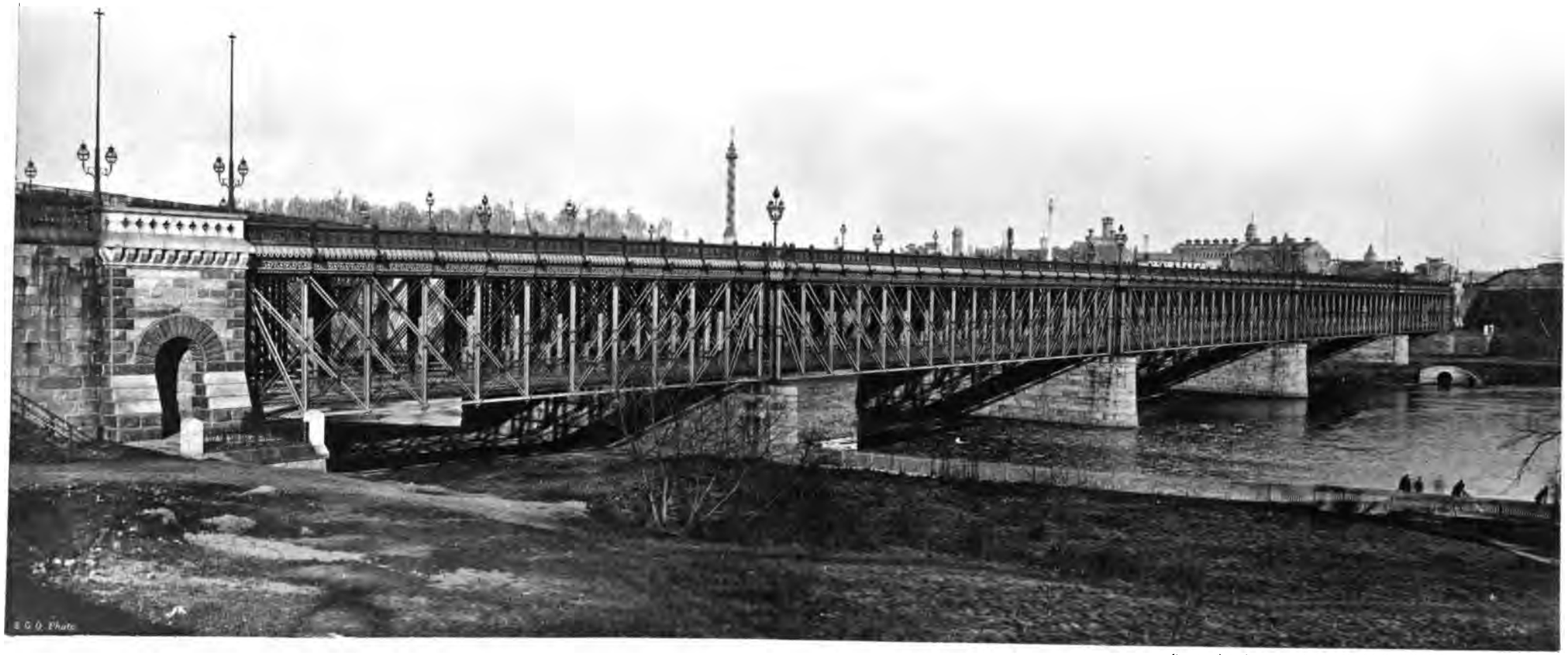
ALBANY AND GREENBUSH BRIDGE, ALBANY, N.Y:

Bridge built for double-track railway above and roadway below.

One draw span, 400ft. long; two spans, 250ft. each; three spans, 100ft. each; six spans, 36ft. each. Weight of iron, 2,500 tons.

Plate No. 68.

Page 62



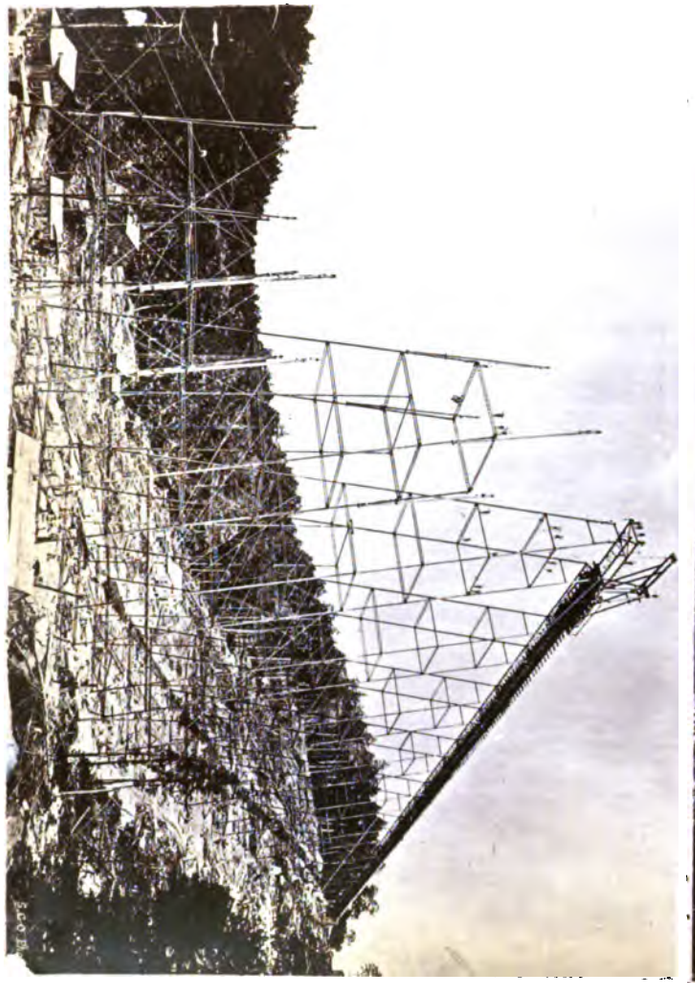
Designed and constructed by CLARK, REEVES, & CO. 1873-4.

GIRARD AVENUE BRIDGE, PHILADELPHIA:

1,300 ft. in length. Width 60 ft. Height 70 ft.

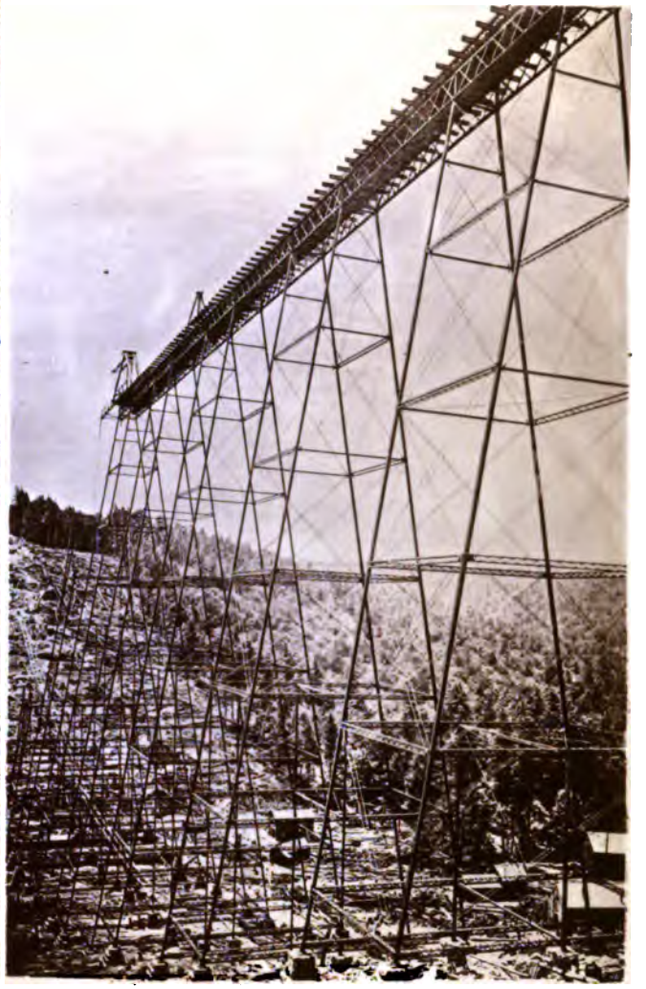
Plate No. 73.

Page 66.



CLARKE, REEVES, & CO., designers and contractors, Phœnixville Bridge Works, Pa.

Showing piers and spans.



From the north end of the Viaduct.

KINZUA VIADUCT.

New York, Lake Erie, and Western Railroad Co. 1882.

Spans, **40***ft. and* **60***ft. alternately. Total length,* 2,052*ft. Height at centre,* 301*ft. Weight,* 1,562 *tons.*

Plate No. 74.

Page 66.

Constructed by the Keystone Bridge Co., U.S.A.

BRIDGE OVER THE RIVER OHIO:

Cincinnati Southern Railway.

		Span 1. ft. in.	Span 2. ft. in.	Span 3. ft. in.	Span 4. ft. in.	Span 5. ft. in.
Length, centre to centre—	*Piers*	110 0	370 0	519 0	300 0	300 0
Depth "	*Chords*	15 6	36 6	51 6	37 0	37 0
Width "	*Trusses*	10 0	15 6	20 0	15 10	15 10

Total length, 1,599 *ft. Total weight*, 2,171 *tons.*

Plate No. 75.

Page 66.

Designed and constructed by COFRODE & GAYLOR, Phila., Pa.

BRIDGE OVER THE RIVER OHIO, AT BEAVER, PA.:

Lake Erie Railway.

Length of spans—*No.* 1, 30*ft.*; *No.* 2, 180*ft.*; *No.* 3, 440*ft.*; *No.* 4, 260*ft.*; *No.* 5, 230*ft.*; *No.* 6, 230*ft.*
Height of truss centres of chords, 42*ft.* 2*in.* *Distance apart centres of trusses*, 18*ft.*
Height from L. W. to base of rail, 95*ft.* *Viaduct approach*, 1,080*ft. lineal.*

Designed by BRUCE & BAIRD. *Manufactured by* HAWKS, CRAWSHAY, & SONS.

HYDRAULIC DREDGER:

To dredge about 250 tons per hour from a depth of 25ft.

Length over all, 130ft. *Beam*, 26ft. *Depth*, 9ft.

SMALL HYDRAULIC DREDGER:

For [illegible] works as supplied to the Government [illegible]

To dredge 100 tons per hour to a depth of 15ft

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K.F. W...
UW COLLEGE C...
215 N. R...
MADISON, WI 5...